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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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PADDLE OR SCREW STEAMERS OF
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Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3561
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Specification and Workmanship equal to Main Line Locomotives.
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See page 76. 5020

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Quantity of Crude CAUSTIC SODA FOR DISPOSAL, and would like to get into touch with users.—Address D 830, Offices of ENGINEERING.

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Compound wound Dynamo, 500 volts. Could be easily altered to 250 volts. Immediate delivery; cheap.
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CARDIFF WAREHOUSE—132, BUTE ST.
BIRMINGHAM WAREHOUSES — BROAD STREET CHAMBERS, SHEEPCOTE ST., and 10, COLMORE ROW.
See Advertisement page 26. 4990

Craig & Donald, Ltd., Machine
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For class of Machine Tools see our Illustrated Advertisement every alternate week. 1358

Electric Motors for Sale,
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— FOR —
EXHAUST STEAM TURBINES. COMPRESSED AIR, &c.
STEAM DRYERS,
METALLIC PACKINGS.
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Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON AND BRASS CASTINGS.
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See Illustrated Advt. in alternate issues. Od 3382

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SHELL DRILLING MACHINES.
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CAPITAL (Fully Paid) - - $6,000,000
SURPLUS & UNDIVIDED PROFITS $9,000,000
This Bank receives Accounts of Banks, Bankers, Corporations, Firms and Individuals on favourable terms, and grants to its depositors every facility consistent with prudent and conservative banking methods.
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Boilers, Tanks & Mooring Buoys
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See Advertisement page 36, March 17. 2402

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See Illus. Advt. last week, page 17. 4812

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 4638
See Full Page Advt. page 44, March 10.

Taylor & Challen, Ltd.,
BIRMINGHAM. 3196
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PRODUCTS.
See Advertisement, March 10, page 45.

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To Let, on Hire, with Com-
petent Men, Fowler 8 HP. three-speed ROAD LOCO. and Wagons; also 5-ton Compound Tractors with Trailers and Foden Wagons. All plant is in perfect condition and less than one year old.—CHARLES OPENSHAW, LTD., Broadway Buildings, Reading. D 660

One Powerful Economic
MULTI-TUBULAR BOILER (Second-hand), 9ft. 0 in. dia. by 14 ft. 6 in. long, suitable for 160 lb. w.p. DESPATCH IMMEDIATELY. 5000
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Steam Hammers,
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QUICK DELIVERY. LARGE STOCK.

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For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam.
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Founded 1854 by Sir W. FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5160

OFFICIAL NOTICE.

Trading With the Enemy ACTS, 1914-16.

Attention is called to the provisions of the Trading with the Enemy Acts, 1914-16, which require notice to be given to the Public Trustee of:—

1. Shares in firms or companies held by enemies.
2. Property held in any capacity for enemies.
3. All bank balances held for enemies.
4. Debts of £50 or upwards due to enemies.

N.B.—An enemy for this purpose is any firm or person, irrespective of nationality, residing or carrying on business in enemy territory.

Failure to give notice as required by the Acts is punishable on conviction by fine and imprisonment.

THE RESTRICTIONS ON DEALING WITH ENEMY PROPERTY WILL CONTINUE TO APPLY TO PROPERTY WHICH IS NOTIFIABLE TO THE CUSTODIAN AFTER THE PRESENT WAR, UNTIL SUCH TIME AS THEY MAY BE REMOVED BY ORDER IN COUNCIL. DEBTS OF ANY AMOUNT DUE FROM, AND BRITISH PROPERTY OF ALL KINDS IN, ENEMY OR OCCUPIED TERRITORY MAY ALSO BE RECORDED.

All necessary forms may be obtained on application to the undersigned.

C. J. STEWART,
Public Trustee,
Custodian for England and Wales.

Public Trustee Office,
Kingsway, W.C., D 879
6th March, 1916.

OXY-ACETYLENE WELDING FOR WAR SERVICE.

The Council of the British ACETYLENE & WELDING ASSOCIATION

take pleasure in announcing that they have now inaugurated a CONSULTATIVE DEPARTMENT for the purpose of assisting in the elucidation of welding problems GRATUITOUSLY. The intention is to give expert advice and technical assistance where desired.

Apply to THE SECRETARY, The British Acetylene and Welding Association, 108 and 104, Cheapside, London, E.C. 5168

Inst. C.E., Inst. Mech. E., and all Engineering Exams. Correspondence coaching by practical engineers. I.C.E. successes 282 out of 310. Two Bayliss Prizes, "Proxime Accessit." Special features for foreign candidates. Write for booklet, &c.—Address, 3548, Offices of ENGINEERING.

A National Need.

BRITISH SCHOOL OF AERONAUTICS.
Aeroplanes and Airships. Construction, Design and Draughtsmanship. Also preparation for A.M.I.E.E., A.M.I.M.E. and A.M.I.C.E. Complete Postal Courses.
Fees Reasonable. Instalments taken.
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STRUCTURAL ENGINEERING.

For Particulars of Course of INSTRUCTION by CORRESPONDENCE, write to "THE WESTMINSTER ENGINEERING BUREAU," 23, Old Oak Road, Acton Park, London, W. 4821

TENDERS.

EAST INDIAN RAILWAY.

The East Indian Railway Company is prepared to receive

Tenders for the Supply and DELIVERY of:—

(1) GADVANIZED STEELWORK,
(2) PIG IRON,
(3) STEEL MATERIAL,
(4) WROUGHT IRON,

as per Specification to be seen at the Company's Offices.

Tenders are to be sent to the undersigned, marked "Tender for Galvanized Steelwork," or as the case may be, not later than Eleven o'clock a.m., on Wednesday, the 5th day of April instant.

The Company reserves to itself the right to divide the order, also to decline any Tender without assigning a reason, and does not bind itself to accept the lowest or any Tender.

For each Specification a fee of £1 1s. is charged which cannot under any circumstances be returned.

By Order,
C. W. YOUNG,
Nicholas Lane, London, E.C. Secretary.
22nd March, 1916. D 899

BY ORDER OF THE CATTLE MARKETS COMMITTEE OF THE CORPORATION OF LONDON.

Offers are Invited for MACHINERY and BOILERS as fixed in premises at the Foreign Cattle Market, Deptford, S.E.

The PLANT includes Horizontal Engine (56 B.HP. maximum load), by Marshall & Sons, Gainsborough; an Ammonia Refrigerator, complete, by the Haslam Foundry Co.; a Dynamo, complete, and Two Lancashire Boilers, length 24 ft. 4 in., diameter 8 ft., and fittings.

Further information can be obtained, and an appointment to view arranged, on written application to the Clerk and Superintendent at the Market.

Offers for the whole or any of the Machinery, &c., must be addressed, in a sealed envelope, to the Town Clerk, Markets Department, Guildhall, endorsed "Tender for Machinery," to reach me by Monday, 17th April, 1916.

Guildhall, BELL.
March, 1916. D 868

GREAT NORTHERN RAILWAY COMPANY (IRELAND).

The Directors are prepared to receive

Tenders for the Supply of ONE 5-Ton HAND WHARF CRANE.

Particulars may be obtained from the Secretary on payment of Five Shillings, which will be refunded on receipt of a *bona fide* Tender.

Tenders should be delivered, under sealed cover endorsed "Tender for Hand Wharf Crane," to the undersigned, not later than Ten a.m. on Monday, the 3rd April, 1916.

The Directors do not bind themselves to accept the lowest or any Tender.

T. MORRISON,
Secretary.

Secretary's Office,
Amiens Street Terminus, Dublin,
22nd March, 1916. D 892

APPOINTMENTS OPEN.

ELSWICK TECHNICAL INSTITUTE, NEWCASTLE-UPON-TYNE.

Head Master Required, to direct and control the Technical and Engineering Evening Classes for Session 1916-17. Must have Engineering qualifications.

Applications, stating experience and salary required, to be sent to the SECRETARY not later than 10th April. D 853

TECHNICAL INSTITUTE, WIMBLEDON.

Engineering Instructor, Practical, WANTED or Workshop Practice. Salary £130 per annum. Must be ineligible for military service.

Form of application and further particulars may be obtained from

W. A. HARWOOD, Principal, D 843
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Gladstone Road, Wimbledon.

Works Manager Required.

IMPORTANT APPOINTMENT.

There is a VACANCY in large Engineering Firm (3000 hands), whose manufactures are of high-class and repetition character, and at present engaged on War work, for a First-class Energetic WORKS MANAGER.

The appointment is only open to those who can show they have successfully filled a similar position, and are highly experienced in obtaining the maximum of output, in the discipline of men, and in general organisation and works efficiency.

The salary offered is specially high to attract applications of first merit.

Address, in first instance, to D 852, Offices of ENGINEERING. All correspondence will be treated with strict confidence.

Wanted, Works Manager for small Engineering Works in the Midlands; Six o'clock man, with good knowledge of machine tools. No one already employed on Government work need apply. State full particulars.—Address, D 886, Offices of ENGINEERING.

Mechanical Engineering Glasgow Firm, manufacturing light and precision specialities (Government work) requiring careful inspection and supervision, REQUIRE immediately ASSISTANT to their technical manager to superintend such work; previous experience unnecessary, but technical training preferred. State full particulars ann terms.—Address D 902, Offices of ENGINEERING.

Russia.—Capable and Ener- getic Commercial ENGINEER REQUIRED, who has had sound business experience in European Russia. Must be trained engineer, thoroughly conversant with Russian business and able to speak and write fluent Russian and English.

Applications, which will be treated in confidence, must give full particulars of technical and business experience, age, and salary required.—Address, D 809, Offices of ENGINEERING.

Power Station Superintendent REQUIRED for large A.-C. three-phase 2000-volt plant, to take complete charge. Government work in partly controlled establishment. Please state age, particulars of training and experience, salary desired and date at which services available.—Apply your nearest LABOUR EXCHANGE, quoting No. A 1644. No person on Government work will be engaged. D 900

Wanted, Immediately, for the East, thoroughly qualified STEEL WORKS ENGINEER or Master Mechanic. Some marine experience an advantage. Age between 40 and 48. To be responsible for millwrighting and upkeep of entire steel works plant. Only first-rate men considered.—Address, D 869, Offices of ENGINEERING.

Wanted, at Once, for special work under the Admiralty, First-class DESIGNER, capable of original work, with experience in shops. Applicant should state whether he has studied aviation design, and what his experience is in that subject.—State salary required, by letter, BOX No. 629, care of STREET'S, 8, Serle Street, London, W.C. D 870

Wanted, Two First-class Jig and Tool DESIGNERS, for aircraft engine work in the Midland district; must have had experience on similar high-class repetition work, and good knowledge of machine tools. State age, experience, salary required, and when at liberty. No person already engaged on Government work need apply.—Apply to your nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper, and D 834.

One or Two First-class DRAUGHTSMEN REQUIRED, preferably with experience of hydraulic plant and steel works machinery. No person already employed on Government work will be engaged. State experience, age, salary required, and when at liberty.—Apply to the nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this Journal, and D 512.

Capable Draughtsman Re- QUIRED, experienced in steam turbine work.—No person already employed on Government work will be engaged.—Full particulars, age, experience, and salary required to nearest LABOUR EXCHANGE, mentioning this Journal and D 766.

Wanted, for Government work, in Derby,
CHIEF TOOL DRAUGHTSMAN,
experienced in the design of tools for automatic and hand turret lathes.

It is essential that applicants should have had experience in the manufacture of small accurate parts.

No man on Government work need apply.

Apply, stating age, experience, salary expected, and a reference, to the nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and No. A 370. D 775

Competent Draughtsman, for gold and silver mining plants, REQUIRED immediately in London. Must be ineligible for military service. No one resident more than 10 miles away, or already engaged on Government work, need apply.—Write, with copies of testimonials, stating age, experience and salary required, to Z. K. 721, care of DRACON'S, Leadenhall Street, E.C. D 881

Wanted, a Draughtsman, for instrument and small machine war work. No person more than 10 miles away or already engaged on Government work will be engaged.—Apply to R. & J. BECK, LTD., Lister Works, Weedington Road, Kentish Town, N.W. D 885

Wanted, by Midland Engi- neering Firm working under Government control, first-class DRAUGHTSMAN, having general mechanical engineering experience. State age, experience, salary required, and when at liberty. No person already engaged on Government work need apply.—Apply to your nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this Journal, and D 854.

Wanted, for Perth, DRAUGHTSMAN, experienced in general, civil or municipal engineering.

Candidates must produce evidence of ineligibility for military service. Salary not exceeding 57s. per week.

Apply, stating particulars of experience, age, when disengaged and enclosing copy of testimonials, to SUPERINTENDING CIVIL ENGINEER, Admiralty Works' Department, St. Leonard's Bank, Perth. D 882

Wanted, Immediately, by large munition works, several good DRAUGHTSMEN, for general work; modern machine tool experience a recommendation, but not essential. None but first-class men of long experience need apply. State wages required and full particulars. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and D 834.

Wanted, in Government Office on South Coast, CIVIL ENGINEERING DRAUGHTSMAN, ineligible for military service.

Send full particulars, and state salary required, by letter, to BOX No. 623, care of STREET'S, 8, Serle Street, W.C. D 880

Draughtsmen Wanted, for aeroplane work; any man capable of adapting himself to above may apply. Applications treated confidentially.—Write to your nearest LABOUR EXCHANGE, mentioning this paper and No. A 1619. No person on Government work will be engaged. D 834

Wanted, for Government work, in Derby, several
ASSISTANT TOOL DRAUGHTSMEN.
Experience in milling jigs, drilling jigs, or Cleveland automatics essential.

Applicants should have had good technical training, and preferably experience in the shops.

No man on Government work need apply.

Apply, stating age, experience, salary expected, and a reference, to the nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and No. A 371. D 776

Wanted, Junior Draughts- MAN. One with previous knowledge of grinding and crushing plant preferred.—State full particulars and salary to your nearest LABOUR EXCHANGE, mentioning this Journal, and D 861. No person already employed on Government work will be engaged, and must be ineligible for service.

Draughtsman, Junior, Wanted or smart, well-educated Youth willing to learn. No one eligible for military service, resident more than 10 miles from Charing Cross, or already engaged on Government work, will be employed.—Address, D 901, Offices of ENGINEERING.

Wanted, for a Works near Swansea, a PROCESS FOREMAN, for shift work. Must be energetic, capable of picking up a simple chemical process, and looking after men. State age, previous employment, and wages required. Also send copies of references.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 1623. No person on Government work will be engaged. D 855

Foreman Miller, Experienced Man accustomed to modern methods, who must have held similar position; also ASSISTANT FOREMAN (must furnish good references) for motor works in the Midlands; also a FOREMAN for machine department (about 60 machines), small capstan and bar lathes; must be accustomed to accurate work, and held similar position for some years, and able to furnish good references. Good pay. No one already on Government work need apply.—Write, nearest LABOUR EXCHANGE, mentioning this paper, and reference A 1589. D 749

Wanted, Boiler Maker, Working Foreman, over about 35 men constructing small water-tube boilers and light plate work, in controlled establishment doing Admiralty work only. Permanent situation to suitable man. District, Eastern Counties. State experience, age and wages required. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and D 845.

Foreman Engineer for small launch building and repair works. Good experience in building small machinery and general repair work, estimating cost, &c. A knowledge of petrol motors and electrical fittings would be of advantage. Permanent employment to an energetic capable man. Non-eligible preferred. No person already employed on Government work will be engaged.—Address, giving full particulars of experience and wages required, nearest LABOUR EXCHANGE, mentioning this Journal and D 767.

Foremen and Assistant FOREMEN, several first-class, for machine shop in the Midlands. Applicants must have held similar positions, and have up-to-date experience with turrets, capstans and centre lathes. Good wages and permanent positions to the right men. None on Government work need apply.—Write, giving fullest details, to your nearest LABOUR EXCHANGE, quoting reference A 1602. D 709

Wanted, Machine Shop FOREMAN, accustomed to modern methods of manufacture, with experience of 3.5 shells preferred; Manchester district. No person already employed on Government work will be engaged.—Apply to the nearest LABOUR EXCHANGE, mentioning this Journal and D 802.

Wanted, Machine Shop FOREMAN, for Bolton works. Must be a first-class man, with thorough knowledge of milling, turning, planing, and slotting machines; also good organizer. No one already employed on Government work will be engaged.

Apply, stating wages required and full qualifications to your nearest LABOUR EXCHANGE, mentioning this paper and D 793.

Munition Factory Requires several JIG and TOOL MAKERS, also INSTRUMENT MAKERS and TURNERS, willing to learn to Operate and Set-up Cleveland, Gridley, and Brown and Sharpe automatic machines. No person already engaged on Government work will be considered.—Apply, in first case, to the nearest LABOUR EXCHANGE, mentioning this Journal and C 870.

Engineering Pupil.—Vacancy with Firm (Government Contractors) manufacturing latest types of machinery, oil and gas engines, &c.; moderate premium.—Address, 6521, Offices of ENGINEERING.

Pupil. — The Borough and Waterworks Engineer (A.M.I.C.E.), of Leamington, has a VACANCY in his office for a PUPIL.—Address, TOWN HALL. C 848

A Large Firm of Engineers, in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of ENGINEERING.

SITUATIONS WANTED.

Secretary-Accountant (age 38) DESIRES similar POSITION; 20 years' experience in engineering, accountancy, buying and office management. Thoroughly capable and reliable. Excellent references.—H. NORRIS, 28, Casseldon Road, Harlesden, N.W. D 859

General or Works Manager, of wide and varied experience, will shortly be OPEN for RE-ENGAGEMENT. Successful Organiser, accustomed to control Large High-class Engineering Works.—Address, in first instance, D 871, Offices of ENGINEERING.

Engineer, for many years employed by well-known firm of world-wide reputation, is PREPARED to UNDERTAKE MANAGEMENT of sound established business, or any really responsible post. Good commercial man, energetic and capable organiser. Would accept nominal salary if engaged on war munitions. Highest references.—Address, D 894, Offices of ENGINEERING.

Advertiser Requires Situation as manager or foreman; considerable experience as manager of works with munition contracts (gauge making, &c.), electrical, motor and general engineering; micrometer, vernier, slide rule. Excellent testimonials.—Address, D 878, Offices of ENGINEERING.

Advertiser Requires Situation as manager or foreman in any branch of engineering. Has considerable experience as manager of works. Well up in millwright work and all kinds of modern machine tools, and general engineering work. Thoroughly practical. Just returned from India. Willing to go abroad.—Address, D 807, Offices of ENGINEERING.

Construction Engineer, 16 years' world-wide experience railways, drainage, irrigation, hydraulic, five languages (32), single. Ineligible, DESIRES POST, home or abroad. Highest references.—Address, BOX 129, SMITH'S Book shop, York. D 858

Mechanical and Electrical Engineer (31), ineligible for the army, having had exceptional commercial experience, SEEKS responsible POSITION, preferably Lancashire district. At liberty any time. Large remuneration not essential if with good prospects.—D 875, Offices of ENGINEERING.

Engineer, A.M.I. Mech. E., practical all-round experience, 1st class Board of Trade certificate, DESIRES APPOINTMENT as works manager, engineer, head foreman, or similar responsible position.—Address, D 887, Offices of ENGINEERING.

Engineer (42), Marine and Mechanical, M.I. Mech. E., DESIRES POSITION as chief engineer on works. Large experience on shipyard and steelworks plant, munition works.—Address, D 866, Offices of ENGINEERING.

Experienced Draughtsman, over military age, not on Government work, SEEKS RE-ENGAGEMENT; accustomed to gas works plant, with large experience in the design and working of sulphate, tar and sulphuric acid plants. Advertiser has had sole charge of the complete erection and working of these plants abroad.—Address, D 889, Offices of ENGINEERING.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of the above Institution was held on Friday last, the 17th inst., at the Institution of Civil Engineers, Great George-street, Westminster, the President, Professor W. C. Unwin, F.R.S., occupying the chair.

The minutes of the previous meeting were first read, and it was announced that six transferences had been made from the class of associate member to that of full member.

THE COMPOSITION OF THE EXHAUST FROM LIQUID-FUEL ENGINES.

A paper entitled "The Composition of the Exhaust from Liquid-Fuel Engines" was next read in abstract by the author, Second Lieutenant Robert W. Fenning, R.E. (T.), B.Sc., D.I.C., of London. This paper we print in full in another part of this issue, and therefore proceed to the discussion.

Professor H. L. Callendar, of the Imperial College of Science, opened the discussion. He said that, while appreciating the compliment of being asked to speak, he feared he could add little in the way of pertinent or satisfactory criticism, not having himself personally conducted experiments of the kind. The work had, however, been carried out in his laboratory, and nominally under his direction; he would therefore like to say a few words in relation to it.

The speaker was glad to see from Lieutenant Fenning's paper that that gentleman's experiments had led to the conclusion that the phenomena concerned were extremely simple if only the combustion were complete, the object, of course, which ought always to be aimed at in an engine. As Lieutenant Fenning had explained, complete combustion would not necessarily be obtained when dealing with the combustion vessel, unless sufficient electrolytic gas were put in to raise the temperature of the explosion and to burn the product completely; otherwise curious results, due to partial or incomplete combustion, might follow. That one condition, however, being satisfied, there was apparently very good agreement between the results of quite simple experiments in a small explosion vessel and those that would be obtained by the actual running of an engine. Another point of interest in Lieutenant Fenning's conclusions was the absence, contrary to the belief hitherto entertained, of a lot of hydrocarbons in the exhaust, provided only that the temperature of explosion had been sufficiently high and the gases sufficiently well mixed.

Dr. Dugald Clerk, F.R.S., was the next speaker. He was, he said, the more interested in the subject because he had conducted what he believed were the first experiments that were made on a large scale for determining the products of combustion from petrol-engines. At the Royal Automobile Club a start was made with the trial of about forty cars, with forty different engines, running on the road. The speaker had designed an apparatus to take exhaust gas from these cars under different and difficult conditions on the road. These gases had all been analysed to find the amount of imperfect combustion. The main thing that emerged from the tests was the surprising quantity of carbonic oxide obtained under certain circumstances. He (the speaker) had, of course, at once seen that the reason for the excess of carbonic oxide was too little oxygen and too much hydrocarbon. A few months later he made some further tests, on a car of his own, which he ran to find out exactly what was the amount of unburnt gas and the proportion of hydrocarbon in the unburnt gas. As a general result of all the experiments in 1907, he had prepared a paper early in that year, and had read it before the Institution of Automobile Engineers. He had come to the conclusion that in many engines as much as 39 per cent. of the total carbon present in the original petrol was discharged as carbonic oxide and 5.6 per cent. as methane. Nearly 45 per cent. therefore of the original carbon of the petrol had not been completely burnt or not burnt at all. From that he had determined by calculation that about 30 per cent. of the total heat of combustion had not been evolved at all in the case of an engine with too much petrol. Not only so, but a very strong mixture (as Lieutenant Fenning had pointed out), where there was just sufficient oxygen to burn the whole of the carbon and hydrogen present, was, of all mixtures, the least economical to use in a petrol or any other internal-combustion engine. The speaker had, also in 1907, described, at the Institution of Civil Engineers, a series of experiments on the specific heat of the products of combustion, and he had come to the conclusion that the specific heat had altered the efficiency of the air standard to an extent of about 20 per cent. He had then been able to show that the weaker the mixture—so long as it could be fired and maximum pressure and complete combustion could be obtained—the higher was the thermal efficiency of the particular diagram. The thermal efficiency increased and tended towards a limit, that limit being reached when there was nothing but pure air; the nearer the approximation to pure air in the cylinder the higher became the thermal efficiency. The speaker had seen diagrams taken from a petrol engine using extremely dilute mixture at high compression, and these diagrams showed an efficiency of about 80 per cent. of the air cycle. In 1907 the highest efficiency he had obtained was 71 per cent. of the air cycle. In the case under consideration the efficiency was 80 per cent., with a very weak mixture and strong firing arrangements to burn that mixture. Of course, the most economical mixture for a motor-car—it was usual to want maximum power—was somewhere about the point marked O_2 in the author's diagram, Fig. 3 (see page 291 in this issue). At that point a mixture was obtained which fired readily, and, at the same time, there was a lower specific heat and less heat loss; in that way a good mixture was got. Professor Callendar and Lieutenant Fenning had remarked that the matter was very simple once there was complete combustion, and it was possible to get complete combustion in the engine-cylinder with a certain range of mixture; but if the mixture became too dilute there would be a flame which spread very slowly through the mass, and in such a mixture there might be the peculiarity noted by Lieutenant Fenning—*i.e.*, both excess of oxygen and carbonic oxide present. The speaker had made many experiments in closed vessels with very weak mixtures, and had found in some cases that with a very small rise of pressure the flame suddenly went out. On analysing the contents of the cylinder, both carbonic oxide and excess of oxygen would be found together; the condition was quite common. He had made certain other experiments. When the British Association Gaseous Explosions Committee had just started, he had the honour of working with Dr. Watson for the first time. Dr. Watson began, after discussion, a most interesting set of experiments, which had culminated in the paper presented by Lieutenant Fenning. Dr. Watson had been a most indefatigable worker on gas and petrol-engines, and internal-combustion engineers were greatly indebted to him for many accurate results; many things broadly known were determined by him with the utmost physical and chemical accuracy. In 1907 the speaker had come to the conclusion that there might be a good many reasons for imperfect combustion. He had stated, firstly, that there might be too rich a mixture with insufficiency of oxygen. Again, there might be too weak a mixture with excess of oxygen, but too slow a rate of ignition and combustion. Then there might be an irregular mixture with bad carburetting. In engines like the Diesel engine, where spraying was used, if the spraying were done in too large drops, the combustion would be very imperfect indeed. There might be an irregular mixture, too rich in one part of the stroke and too weak in another—a bad mixture. Much depended on the shape of the cylinder. If the carburettor were too cold, with certain mixtures it would be difficult or impossible to fire; missing and bad mixture would result, as a consequence partly of low temperature and partly of bad carburetting. If the timing of ignition were wrong, accompanied by the missed ignitions to which Lieutenant Fenning had referred, there would be partly-burnt charges mixing with the exhaust and spoiling the analysis. The speaker had always noticed that if, when running under light loads, the ignition was in the body of the cylinder instead of the port, the consequence was always irregular running and irregular results. With complete combustion, however, as Lieutenant Fenning had shown, the matter was very simple. The broad rule was this, that to get complete ignition, complete combustion and no losses, it was necessary to have as weak a mixture as could be fired; that was the position of maximum economy. This rule had stood through all the experiments that had been made. In conclusion, Dr. Clerk expressed himself as much indebted to Lieutenant Fenning. He would frequently use the latter's results in his own work for calculating mixtures. He (the speaker) had some time ago proposed such a method of calculation for determining the nature of the mixture in the cylinder, and he was glad to find that the results of the method had been so accurately set out. It was highly creditable to Lieutenant Fenning that he should have taken such an immense amount of trouble to reconcile the difference between the small bulb and the engine. The use of electrolytic gas to get a complete combustion, which could not otherwise have been obtained in a small bulb, was very ingenious.

Mr. Horace Boot desired to draw attention to the following remark in the author's paper:—"Why not adopt this method when setting carburettors, and thus promote fuel economy, lessen carbonisation, and minimise the pollution of the atmosphere by such poisonous gases as carbon monoxide?" The difficulty of arranging this, the speaker said, was connected with the working load which had to be run by heat engines. Experiment had shown that the mixture had to be varied, but could not be varied in the same ratio as the working load. The measurement of CO_2 had been done by steam engineers for many years in relation to fuel tests, and CO_2 recorders were in every-day use in power-stations. Experience with Diesel engines, using heavy residual oil, showed that careful watching of the temperature of the exhaust gases was a rough-and-ready method of testing what the engine was doing in regard to fuel. It was also well known, in the case of Diesel engine tests, that the colour of the exhaust gases served to indicate roughly the presence or otherwise of the correct amount of air. He would like to ask Lieutenant Fenning whether he had carried out any experiments in the utilisation of the heat of the exhaust from the liquid-fuel engines.

Mr. W. A. Tookey much appreciated the carefulness with which Lieutenant Fenning had carried out such an extensive series of experiments. The paper, consisting largely of tabulated results, did not lend itself to criticism, but, at least, information could be exchanged. The author had explained very lucidly the apparatus that he had used, but the speaker gleaned that there were pieces of apparatus which, from the point of view of the experimenter with internal-combustion engines, were less cumbersome and equally efficient. He himself used an apparatus which would go into a box having the dimensions of 2 ft. by 1 ft. by 6 in., and the method adopted was very similar to that which Lieutenant Fenning had described. The CO_2 content was first obtained, and then the oxygen. For the elimination, or rather absorption, of the heavy hydrocarbons the speaker used bromine instead of sulphuric acid. From that point, however, the method differed from that adopted by the author. The explosion vessel was done away with entirely, and no reliance was placed upon the very varying efficiency of the cuprous chloride solution for the absorption of the carbon monoxide. The system to which the speaker referred was that introduced by Dr. Levy, and consisted in passing a certain portion of the residual or sample, treated in the way the speaker had described, with added oxygen, through a capillary tube containing a platinum wire, through which an electric current passed. The heat could be regulated by means of resistances. By means of two mercury bulbs the gas could be passed and re-passed, time and again, against the platinum wire in the capillary tube. In this way it was possible to see the hydrogen burning, the platinum wire glowing somewhat more intensely than when the current only was passing. Raising the temperature to a higher degree, the heavy hydrocarbons and the carbon monoxide were burnt off. In effect, the remainder of the gases could be passed through the CO_2 absorber, and it was possible to determine by calculation how much carbon monoxide, how much marsh gas, and how much hydrogen had been burned during that one process. He mentioned the foregoing apparatus for the reason that it might serve as a hint to subsequent workers, that an apparatus existed which did not involve quite so many items as that so clearly described by Lieutenant Fenning, and also did not involve so long a period as the five hours mentioned by the author, as complete analyses of samples of gases had been made in it in three-quarters of an hour. In regard

to the use of electrolytic gas, or its equivalent, for the more ready combustion of weak mixtures, engineers might be interested to learn that the gas was used, though not quite in the same way as the author employed it, in connection with the Humphrey pump. It would be known to some that weak mixtures were used in that pump, and also low compression pressures, two conditions thus operating against complete combustion in that pump. It had recently been found that if a small quantity of petrolised air were first of all ignited in an ignition-chamber, and flashed from that into the main combustion-chamber of the pump, all ignition troubles were overcome, and the liability to interruption of working, due to condensed moisture on high-tension plugs, or anything of that kind, was entirely removed. The speaker inquired whether the lubricating oil had not some effect on the constitution of the exhaust and account for the excess CO_2 and oxygen on the author's engine charts.

Lieutenant Fenning, replying to the discussion, desired to state that it was largely due to Professor Callendar that the experiments had been carried out. Dr. Dugald Clerk had referred to the connection between thermal efficiency and mixture strength, and had indicated the best mixture strength from the thermal efficiency point of view, while he had also called attention to the incomplete combustion resulting from bad mixture.

Dr. Clerk had, further, credited the speaker with the introduction of electrolytic gas in relation to these experiments; it was, however, Dr. Watson who had suggested the use of this gas. [Dr. Dugald Clerk here remarked that he had not intended to credit Lieutenant Fenning to quite that extent, as the gas had been used in chemical laboratories before even Dr. Watson suggested its employment. The ingenuity shown was in the particular application of the gas to the experiment under discussion.] Continuing, the author said that the remark quoted by Mr. Horace Boot was perhaps somewhat inane, but he believed that in testing a carburettor to give a good mixture at varying loads it was a good plan to test the exhaust gases. The ideal carburettor was one which would give a constant mixture for varying loads and speeds. The ideal carburettor had to be tested when it was made, and one way of doing this was to test the exhaust gases from it under varying conditions; therefore the connection between the carburettors and exhaust gases was very intimate. With regard to the colour of the flame, the speaker had referred to that point in the paper.

Mr. Horace Boot had asked whether there was any method of utilising the heat in the exhaust. The speaker had not made any experiments in this connection, but believed that there was in existence an engine that used exhaust gases to heat water, a kind of compound engine, an internal-combustion and steam-engine. That was a matter absolutely apart from the question of the composition of exhaust gases.

Mr. Tookey was quite right in his reference to apparatus; there were any number of apparatus for analysing exhaust gases, but the speaker had used the one he described for the reason that it had been found, from experiments carried out in the laboratory by Dr. Watson, to be an extremely efficient apparatus. Although bulky, it was easy to use once the investigator was at home with it. It would present difficulties if it had to be carried about, but in laboratories with plenty of space its bulk was not a hindrance to its use. The speaker had tried the use of bromine for absorbing the heavy hydrocarbons, but found that it attacked the mercury very rapidly, and as mercury was used as a displacer, it was impracticable to employ bromine; fuming sulphuric acid had to be used instead, in spite of its unpleasant fumes; the acid was used very carefully. Mr. Tookey had referred to the employment of a heated platinum wire in connection with the absorption of CO_2, raising the wire to a certain temperature to burn the hydrogen, and yet higher to burn the carbon monoxide and methane. The speaker thought it quite possible to get very good results that way, but he could not speak from his own experience. If, however, the wire glowed rather more vigorously when the hydrogen was burning, was there not a possibility of raising the temperature so high that the small quantity of CO burnt would at once interfere with the results obtained from the contraction? In such a case the results would be apparent only, and would be useless. Therefore the difficult part in the method described by Mr. Tookey would be the regulation of the temperature.

Mr. Tookey here observed that the vessel was water-cooled, to which Lieutenant Fenning replied that the more vigorous glowing of the wire when the hydrogen was burning indicated higher temperature. Mr. Tookey stated that the test for CO followed immediately, whereupon Lieutenant Fenning remarked that that introduced another stage, and lengthened the exhaust-gas analysis.

Continuing, the author said that Mr. Tookey had given three-quarters of an hour as the period of analysis. The speaker's five-hour analysis comprised an absolutely complete exhaust-gas analysis of the first sample, omitting the absorption of the heavy hydrocarbons. Then followed a second exhaust-gas analysis of the second sample, comprising a rather larger volume of explosion mixture, and after that a third check—analysis. Therefore there were practically two complete analyses, followed by a check analysis. No one would think of carrying out an ordinary commercial analysis so completely as that. The object of making such a thorough analysis was simply to make certain, as far as might be, that the results obtained were of some use. It would be possible, with the apparatus described by the speaker, to take an ordinary commercial test for CO_2, CO, and oxygen in about 35 minutes; to absorb hydrogen might take another quarter of an hour. Everything depended upon the degree of accuracy to which it was desired to work; for a high degree of accuracy the time must be prolonged to get good results. In regard to lubricating oil, the speaker had mentioned that the CO_2 by experiment was rather greater than by calculation—he was referring to explosion-vessel tests—when dealing with hexane; in that case there was no lubricating oil. Reference to the chart in Fig. 5 in the paper would show the explosion-vessel curves with the engine exhaust points on them, and it would be seen that these points fell on the CO_2 curve or just below it, so that there was no question of the amount of CO_2 in the engine exhaust exceeding that in the explosion-vessel exhaust. A part of the trouble arose from the small quantity of oxygen that appeared in the exhaust in conjunction with CO. Dr. Clerk had referred to that as a possibility in ordinary engines running under service conditions.

The President then closed the proceedings, after announcing that the next ordinary general meeting would take place on Friday, April 14, when a paper entitled "The Filtration of Water," by Mr. Walter Clemence, would be read and discussed. A further meeting would be held on Friday, May 19 next.

BRAZILIAN MANGANESE.—The exports of manganese from Brazil during the past ten years have been as follows:—

Year.	Tons.	Year.	Tons.
1906	121,331	1911	171,172
1907	236,778	1912	152,431
1908	166,122	1913	180,738
1909	226,982	1914	270,000
1910	249,964	1915	350,000

There have been complaints of late of a shortage of manganese, but it is clear that Brazil has not had much to do with such a difficulty. With the exception of a small quantity produced in the State of Bahia, Brazilian manganese comes from the State of Minas Geraes, which has attained the reputation of possessing mines of all kinds. It is, indeed, the mining region of Brazil par excellence.

"THE UNIVERSAL ELECTRICAL DIRECTORY (J. A. BERLY'S), 1916."—This edition has been as carefully revised as previous issues, and no pains have been spared to make it as accurate and reliable as the former issues. The book is divided into four sections:—The British, with 15,100 names; the Colonial and General, with 7590 names; the Continental, with 7500 names; and the United States, with 5450 names. Each section is subdivided into alphabetical and classified sections, while in the case of the British a geographical section has been added, which is a necessity for all travellers. Any section can at once be referred to by means of a thumb index. Telegraphic addresses, telephone numbers, and codes are given in the alphabetical sections, together with financial particulars of British limited liability companies, also of foreign companies with a British address. The lists of electricity undertakings in the United Kingdom, British Colonies, and some other countries include the following details:—The nature of the supply; system of distribution; capacity of plant; voltage and chief engineer's name; and in the case of alternating current the phase and periodicity are included. A list of specialities appears in the British section, arranged alphabetically according to the name of the article, followed by the maker's or agent's name and address. The price of the directory is 1*l.* 1*s.* post free; or the "A" edition, with the Continental and United States sections omitted, 12*s.*, also post free. It is published by Messrs. H. Alabaster, Gatehouse and Co., 4, Ludgate-hill, E.C.

GRINDING-MACHINES.—No. XXII.

By JOSEPH HORNER.

IN this article it is proposed to illustrate advances which have been made in the designs of headstocks and tailstocks since the series of 1903 was written. The headstocks were treated under the date of June 12, 1903, to which reference may be made for remarks on their general design, and for comparisons with the present later illustrations.

The latest Brown and Sharpe headstock is shown by Figs. 314 and 315. It combines provision for dead and live-centre work, and has adjustable driver pins. The pulley A is for live-centre work, the pulleys B and C for doing that on dead centres, at two speeds. B remains permanently in place, while C is removable, being aligned by a pin *a* and fastened with a screw *b*. When dead-centre work is being done the pulley A is locked with the pin *c*, which is shouldered down to receive the point of the grub-screw below, which controls its in and out movements.

The fitting of the inner dead-centre pulley B is done through the medium of a bushed sleeve. The latter, *d*, is fitted to the spindle with a screw-thread and smooth portion, according to the usual practice. The sleeve is flanged at the outer end to retain the pulley. The latter is bushed, *e*, with phosphor-bronze to run on the sleeve. The two drivers, D, D, for the separate plates, Fig. 315, are pivoted to cover the range of radii required for various work.

The expansion of the spindle and endlong wear are taken up at the front bearing only, against the collar *f* on the spindle through the medium of the nut *g*, which is locked with a grub-screw pressing on a pad. A draw-in chuck, such as shown in Fig. 316, can be used, through the hollow spindle, for holding washers and rings by their bores. The screw E at the front expands the split bush F in the bore. Turning the knob G at the rear draws in the rod H and pulls the bush F against the face-plate.

A Landis headstock for live and dead-centre work is seen in Fig. 317, in which both pulleys remain permanently in position. The live-centre pulley A is attached with screws to a collar, which forms a portion of the spindle. The dead-centre pulley B, bushed with bronze *b*, runs on a bush *a* of hardened steel, with oil-grooves, this bush being screwed to the spindle nose. The spindle is locked by the pressure of a screw-pin (not shown) when dead-centre work is being done. The bushes are parallel and split, by which wear is taken up, the correction being by the wedge-blocks *d*, Fig. 318, in the usual manner. The clamping of the bushes is done by the three screws *c* in the split body encircling the bushes. End play is taken up by the nut at the rear, locked with a clamping-screw. The pivoted work-driver C is fitted.

In the machines by the Bath Grinder Company, of Fitchburg, Mass., U.S.A., the headstock is designed as seen in Figs. 319 and 320. The base swivels around its central bolt, and is located in its axial alignment by a dowel-pin, the graduations locating it for other angles. The live spindle is driven by the hinder pulley A, keyed at the rear with Woodruff keys. The dead-centre pulley B revolves on a conical bush *a*, which is screwed to the spindle nose in the usual way, about half the length only being screwed, the other half plain, to preserve the alignment, and save incorrect strain on the screw-threads when putting it on or removing it. A flange holds the pulley in place on the conical bearing. Slight clearances at back and front permit of taking up wear on the cone. The spindle is locked when dead-centre work is being done.

The headstock by the Cincinnati Grinder Company, of Cincinnati, Ohio, U.S.A. (see Figs. 321 and 322), is distinguished by the use of a single pulley instead of separate ones for live and dead-centre driving. When this pulley A (located centrally as nearly as possible, to afford a pull without torsion) is locked to the spindle by a grub-screw, thrusting a friction-plug B, and the ball-lever screw C which tightens the bush is loosened, the pulley will rotate the spindle directly for live running. To drive on dead centres the process is reversed, the ball-lever C being tightened and the grub-screw above B loosened. The spindle then cannot rotate, but the work is driven on its centre through a set of back gears rotating the face-plate. The two gears are seen at D and E, in Fig. 321, D being

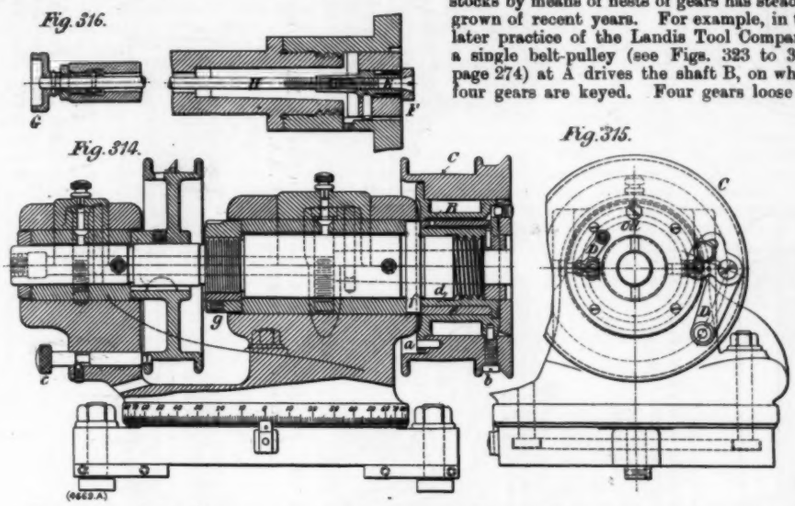
screwed to the pulley A, and E at the back of the face-plate. The pitch circles of gears and pinions are dotted in Fig. 322. Both are protected by the coverings seen in Fig. 322. The driver-plate F runs on a bush of phosphor-bronze a which encircles a bush b that is screwed to the nose of the spindle. The hinder part of the driver-plate is formed as a collar to enter a recess in the head, and so prevent ingress of grit there. To make adjustment for wear, the screws c, c are loosened, and the split headstock casting is compressed by tightening the screw G, Fig. 322. Afterwards the screws c, c are drawn up tightly. End-thrust is taken up by adjustment of the tail-nut H. No play is necessary, because the risks of heating and expansion are nil, the spindle rotating but slowly.

The base of the headstock is graduated into degrees. It is clamped by means of an eccentric fitting seen at J, the pin of which can be adjusted to take up slackness. The felt pads will be noticed, and the oil-grooves cut for the lubrication of the journals and bearings.

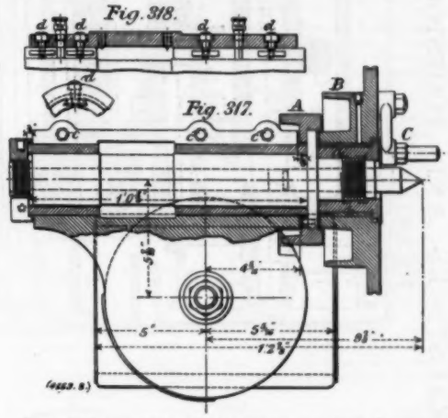
The practice of giving variable speeds to headstocks by means of nests of gears has steadily grown of recent years. For example, in the later practice of the Landis Tool Company, a single belt-pulley (see Figs. 323 to 325, page 274) at A drives the shaft B, on which four gears are keyed. Four gears loose on the shaft C mesh with these, and either one is put into action by a movement of the rod a, seen in section in Fig. 325. This rod has four notches, each matching a corresponding spring-key D in its recess in the shaft C. When the bevelled portion of a spring-key is pushed into its notch in a, the other portion of the key is thrust into the keyway of the gear to which it belongs, so causing that gear to be driven from its mating gear on shaft B, and through it the shaft C. The detail of this fitting is seen in cross-section in Fig. 325, in which the bevelled portion of the key is seen at the left, and the projecting part—the key proper—at the right. There are four key-grooves to increase the chances of catching in, and these are made in hardened-steel bushings b, which are secured to the gear-bores with a pin c.

The different gears are put into mesh by the longitudinal movement of the notched bar a, effected by the pinion d engaging with annular teeth e in one with the collar f, to which the rod a is attached. The four speeds available are produced by the movement of the lever E over the quadrant F. Four holes locate the four positions, and the speeds are either fast or slow from the counter-shaft in the proportion of 4 to 1. There are also three "out" positions for the lever. The speeds are figured on the quadrant.

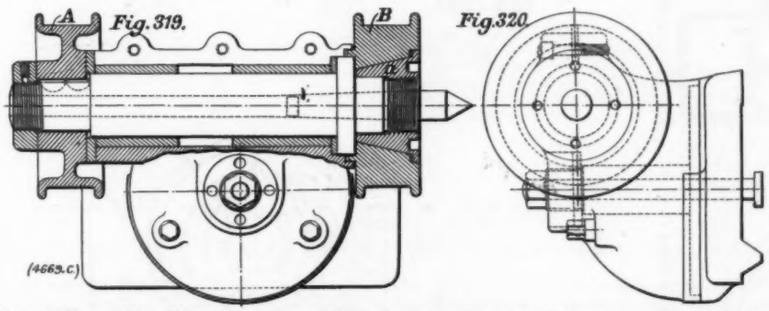
The pinion G keyed on the shaft C drives a gear H on the face-plate J. This runs on the fixed shaft K, clamped by bolts g, g, through a long intervening bush L of phosphor-bronze, lubricated through the hole h. The plate is retained by a ring M screwed on the spindle-nose. The joint is protected by a large ring N, attached to the plate with four screws j, encircling the point-centre closely. The gear-guard O is brought round to embrace the periphery of the face-plate, as shown in Fig. 323. The gear-box is enclosed to form an oil-box, and has a removable cover P, held with screws k. A swivelling work-driver Q is fitted,



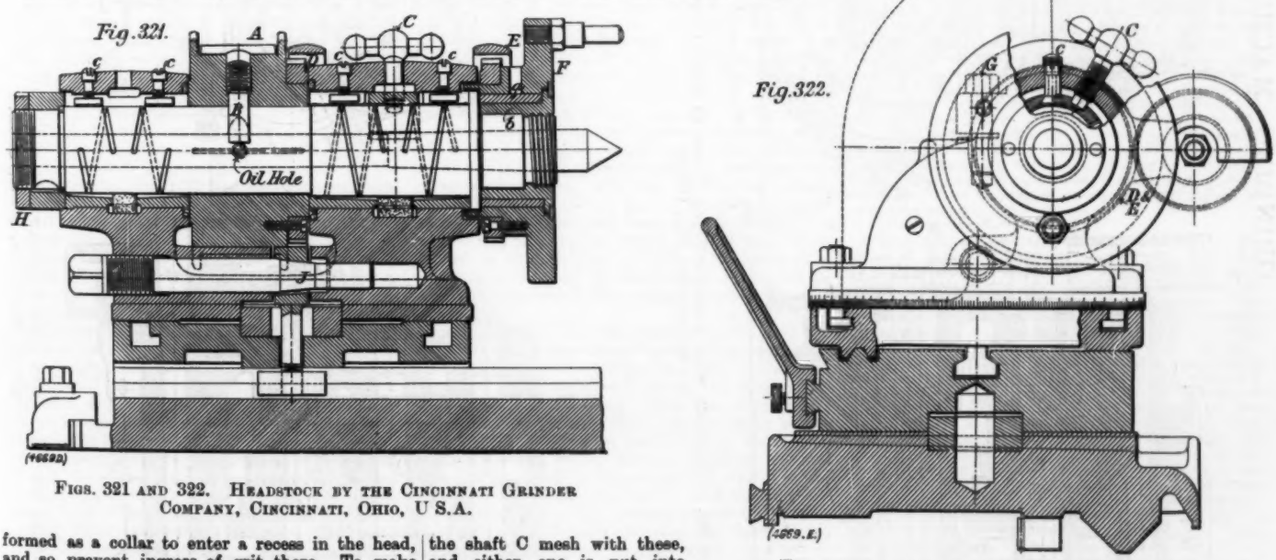
FIGS. 314 TO 316. HEADSTOCK BY THE BROWN AND SHARPE MANUFACTURING COMPANY, PROVIDENCE, R I., U.S.A.



FIGS. 317 AND 318. HEADSTOCK BY THE LANDIS TOOL COMPANY, WAYNESBORO, PA., U.S.A.

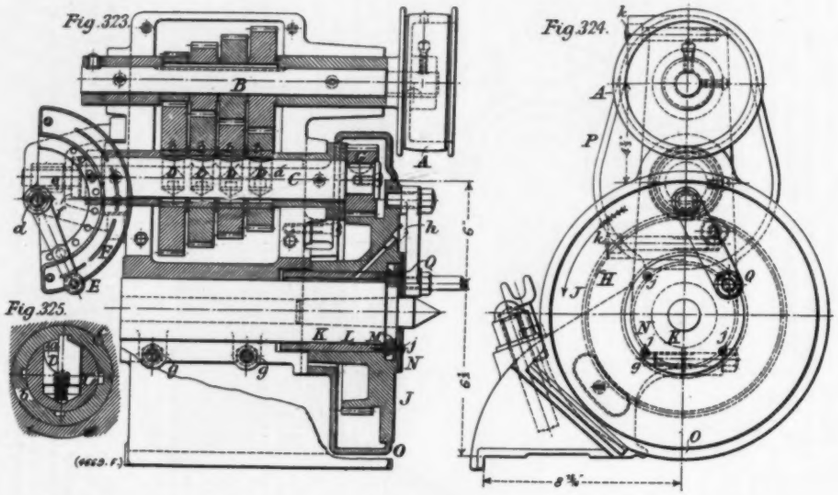


FIGS. 319 AND 320. HEADSTOCK BY THE BATH GRINDER COMPANY, FITCHBURG, MASS., U.S.A.



FIGS. 321 AND 322. HEADSTOCK BY THE CINCINNATI GRINDER COMPANY, CINCINNATI, OHIO, U S.A.

GRINDING-MACHINES; HEADSTOCKS AND FOOTSTOCKS.



FIGS. 323 TO 325. HEADSTOCK WITH VARIABLE-SPEED GEARS BY THE LANDIS TOOL COMPANY, WAYNESBORO, PA., U.S.A.

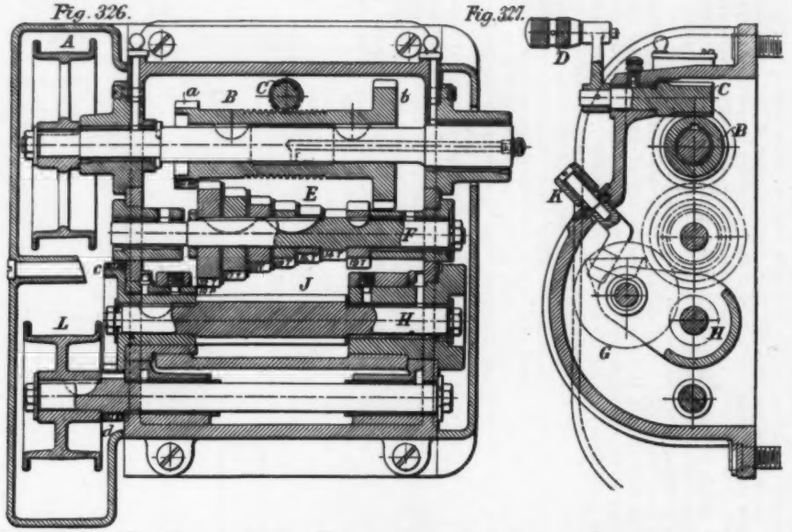
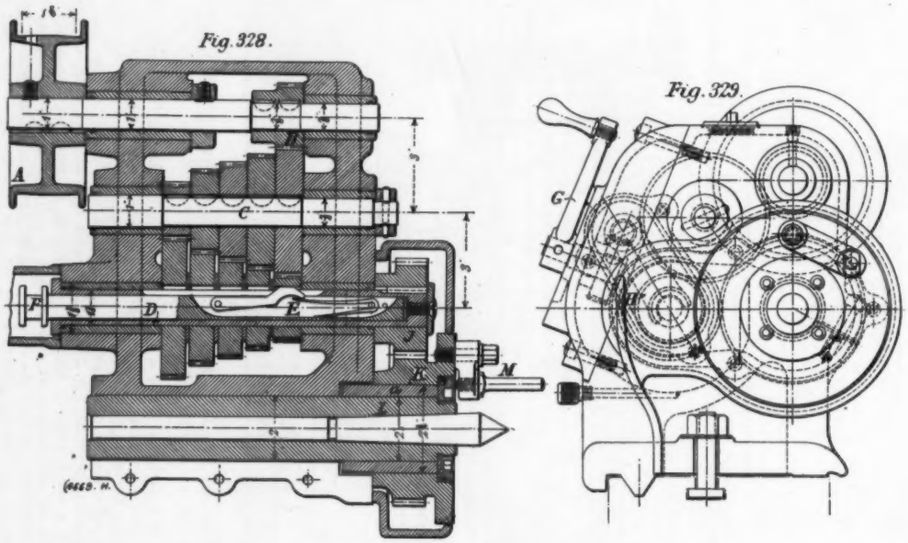
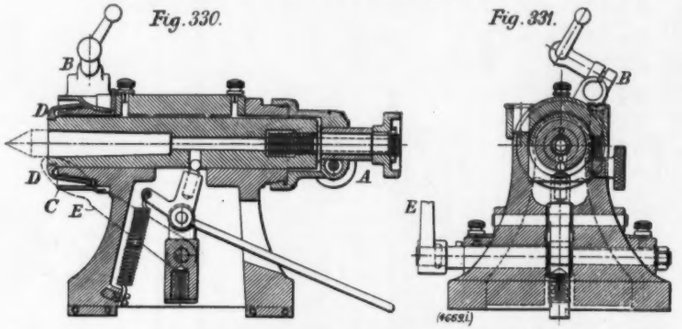


FIG. 326 AND 327. HEADSTOCK WITH VARIABLE-SPEED GEARS BY THE BROWN AND SHARPE MANUFACTURING COMPANY, PROVIDENCE, R.I., U.S.A.



FIGS. 328 AND 329. HEADSTOCK WITH VARIABLE-SPEED GEARS BY THE BATH GRINDER COMPANY, FITCHBURG, MASS., U.S.A.



FIGS. 330 AND 331. FOOTSTOCK BY THE BROWN AND SHARPE MANUFACTURING COMPANY, PROVIDENCE, R.I., U.S.A.

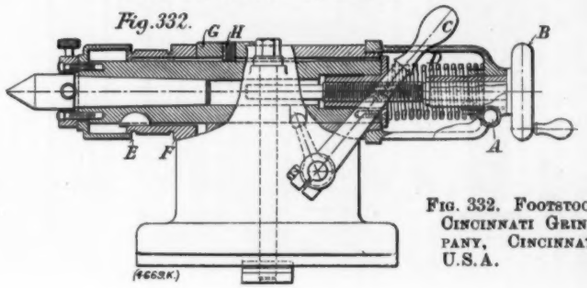
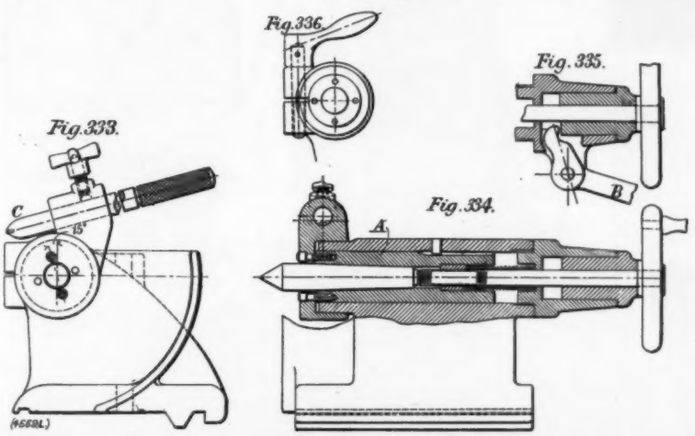


FIG. 332. FOOTSTOCK BY THE CINCINNATI GRINDER COMPANY, CINCINNATI, OHIO, U.S.A.

permitting by its swivel of the control of work of different diameters.

The variable-speed gears for one of the Brown and Sharpe headstocks are shown by the sectional views, Figs. 326 and 327. Here, as is usual, a constant-speed pulley A is utilised, being keyed on a shaft on which the sleeve B is splined to be slid longitudinally by the pinion C and lever D, the "teeth" on the sleeve being rings. Two gears, *a* and *b*, occupy opposite ends of the sleeve, each of which is brought into engagement with its mating gear on the nest of cone-gears E keyed on the shaft F. In this way the speeds obtained by the nest of gears are doubled. The idler-wheel is seen only in the end view, Fig. 327, at G. Its shaft and bearings swing around the axis of the shaft H, and it meshes in all its longitudinal positions with the pinion J of fourteen teeth. G is swung into contact with any one of the nest of gears by a lever that moves over a quadrant in front of the box (not shown), and longitudinally by the lever K, and having a locking-pin for the locating holes. A gear *c* keyed on the end of the shaft H, through a sleeve boss, drives at the variable speeds a gear *d*, on the shaft of the pulley L belted to the headstock.



FIGS. 333 TO 336. FOOTSTOCK BY THE BATH GRINDER COMPANY, FITCHBURG, MASS., U.S.A.

A geared head by the Bath Grinder Company is shown in Figs. 328 and 329, for dead-centre work. Change-speed gears provide five speeds for one speed of revolution of the driving-pulley A. The drive takes place from a pinion B keyed on the shaft of A; it engages with a gear keyed on the intermediate shaft C, which shaft carries four other gears, shown on Fig. 328. These drive five gears running loosely on a hollow shaft D, either of which is put into mesh with its mating gear on the shaft C by the movement of the sliding or "dive" key E, the change being effected by moving the shaft F longitudinally by means of the lever G, seen in Fig. 329. This lever operates through a pinion and circular rack to a forked lever H. The rotation of the gear that is put into mesh is transmitted through the shaft D, and the pinion J keyed on it to K, which is formed in one piece with the driver-plate. This plate runs loosely on a bronze bushing *a* fitting around the fixed spindle L, and secured to it with a short screwed portion. The driver M is pivoted to be adjusted to various carriers or pieces of work. The head is wholly enclosed, and the gears and shafts are lubricated with oil through an opening above, closed with a screwed plug. Dirty oil and sediment are removed through a drain-pipe with cap.

Though the footstocks of grinding-machines bear outward resemblance to the footstocks of lathes, they are modified internally, and for similar reasons to those which cause the steadies of the grinders and those used with lathes to differ materially from each other. The cardinal difference in the footstocks is that the pressure of the work against the poppet centre is resisted by a spring. The object of this is to prevent bending of the work in consequence of rise in temperature. The spring yields, and permits of expansion of the work. Its tension, therefore, has to be delicately adjusted. In short pieces of work, the length of which would be unaffected by temperature, and for face grinding, the spindle is locked, so that the action of the spring does not come into play. Further, the range of endlong movement of the spindle is small by comparison with that of the lathe poppet, chiefly because the latter has to be sometimes used for feeding drills and boring tools, a condition which is non-existent in grinding-machines. A minor difference is that protection has to be afforded to the spindle fittings against the access of dust. If wear occurs, it is usually taken up carefully, since a very minute degree of slack fitting would cause that vibration which is the *bête noir* of the grinder.

Reference may be made to the tailstocks illustrated in ENGINEERING of June 26, 1903, page 844, with which the later examples now to be described may be compared. Figs. 330 and 331, page 274, show the design employed by the Brown and Sharpe Manufacturing Company. Instead of having a coiled spring at the rear of the spindle, one is carried below within the poppet body. A short screw adjustment is effected by the knob at the rear, turning the screw in the end of the spindle. Slight endlong adjustment of the spindle and screw can be made by sliding the short tube A along in its bored seating in the tail-cap, and clamping it with the knurled head and screw. This gives a rapid rough adjustment of the spindle preparatory to the employment of the screw and knob mentioned above. Of course, when the spring action is utilised, the tube A must be left free to slide longitudinally. The split lug B at the front carries the diamond tool for truing the wheel, forming part of a cap C which encircles the front of the poppet cylinder. The front is amply protected by the conical cap D, which is screwed on the nose of the mandrel; as the latter is moved outward the cap D preserves contact with the bore of the outer cap C and covers the taper portion of the main casting, so that no dust can gain access to the barrel. The cap at the rear affords protection there. Wear on the barrel is taken up by removing the cap and scraping a little from the faces. The hole in the barrel has the same taper as that in the headstock spindle. The tailstock is clamped to the bed by the lever E acting on an eccentric into which the clamping-bolt is screwed and locked.

The footstock, Fig. 332, page 274, fitted to the machines of the Cincinnati Grinder Company, combines the screw with a quick-acting lever adjustment. The nut A is tightened when the hand-wheel B is used, and loosened when the quick-acting lever C is employed. When the latter is in use the degree of pressure exercised by the centre against the end of the work depends on the tension of the spring D, the amount of which can be varied by loosening the nut A and turning the hand-wheel B until the desired degree of force is obtained. The distance between the points E and F equals the range of tension which may be obtained, and its amount can be judged when operating the lever C. Wear of the spindle is taken up by removing the cap at G, scraping the flat seats, and tightening up again. A ball handle screwed into the hole at H is tightened when heavy work is being ground between centres.

In the Bath Grinder Company's practice the type of footstock seen in Figs. 333 to 336, annexed, is employed. It has a spring centre, pressure taking place against the quill A, which is bored to a No. 3 Morse taper. Adjustment of the spring tension is effected by the hand-wheel and screw. The lever B, Fig. 335, is for withdrawing the centre, by pressure made against the sleeve adjacent to the hand-wheel. An attachment is fitted to the front of the footstock to form the holder for the diamond tool C.

THE MOTOR TRANSPORT YEAR-BOOK AND DIRECTORY.—This directory, which is issued at the price of 10s. 6d. net, by Electrical Press, Limited, 13 to 16, Fisher-street, Southampton-row, W.C., contains particulars of about 650 undertakings connected with Motor Public Service and the Allied Manufacturing Industries. The information includes the date of registration, the object of the undertaking, its stock, the names of directors, bankers, &c., capital, latest dividends and balance-sheet. A separate section gives the names of about 2000 officials, their addresses, and the names of the undertakings with which they are connected.

NEW FLYING SCHOOL IN AUSTRALIA.—New South Wales authorities have completed negotiations for the establishment of a school of aviation for that State, and arrangements have been made with the Sydney University and Technical College for the immediate commencement of training. It is estimated that 11,000*l.* will cover the expenditure on the buildings, and that the annual upkeep of the school will amount to 6000*l.* The Australian Minister for Defence (Senator Pearce) has stated that there will be no objection to the New South Wales Government utilising the services of military officers at the school when it will not interfere with their regular military duties.

THE NEWSPAPER PRESS DIRECTORY, 1916.—We have received a copy of this directory, the seventy-first annual issue. It is published by Messrs. C. Mitchell and Co., Limited, 1 and 2, Snow Hill, Holborn Viaduct, London, E.C., at the price of 2*s.* It contains about 600 pages of reference to the newspapers, periodicals, and magazines of the United Kingdom, the Colonies, and foreign countries, classified as regards the former under various headings. Interesting statistical data are also given on British trade with the Colonies and foreign countries, together with information on the situation, trade, &c., of a very large number of colonial townships, the information being followed by the titles of the journals published in each. Particulars as to the classes of trade of the foreign countries with Great Britain are also included, followed by the names of the leading political papers and those of the leading illustrated and class papers of the various countries. The book will prove specially useful at the present time.

HIGH-SPEED STEEL SCRAP.—Arrangements have been made by the Ministry of Munitions whereby the makers of high speed steel will take back all scrap, short ends, &c., at uniform prices. The prices which have been fixed are:—5d. per pound for turnings, 6d. per pound for bar ends, delivered at steelmakers' works. All material of this kind should be returned as far as possible to the manufacturer who supplied the original steel. In cases where this is not possible, owing to supplies being obtained from a number of manufacturers, the scrap should be returned in proportion to the quantity of steel which was originally received. The scrap must be packed in convenient-sized barrels, or other suitable cases, and should be free from all foreign substance, and particularly other kinds of steel. Turnings should be returned as soon as a reasonable quantity can be got together and not kept until rusted solid; such scrap is practically worthless. Under the regulations published in the *London Gazette*, dated March 3, as 30 B of the Defence of the Realm Regulations, it is illegal to dispose of high-speed steel through any but authorised channels, and users are therefore advised that the above arrangement should be carried out in every case.

COMMONWEALTH ARSENAL.—Recently, acting on the advice of the British Army Council, the Australian Government sent a Commission to India to make investigations concerning the arsenals there, in order that the experience of India might be of value to Australia. The Commission has since presented its report, most of which is naturally of a confidential nature. A very important point is the recommendation about a site. At every stage in the manufacture of munitions large quantities of water are, it is stated, required, and no site without a plentiful water supply would be suitable. The advice of the authorities in India who were consulted on this matter was, it is pointed out, conclusive. The Commission, therefore, found itself compelled to condemn both the sites which had been previously discussed—the Molonglo River site and the No. 2 site, recommended by the Public Works Committee. In the Molonglo the water supply is reported to be insufficient, and the absence altogether of a water supply adjacent to the No. 2 site removed it from the range of possibilities. The Commission recommends a site on the Murrumbidgee River, about 10 miles from the Capital City and in Federal Territory, as admirably adapted for all the purposes that are likely to be required. The water supply is stated to fulfil all requirements, whilst the other conditions are also favourable. The Minister for Defence has decided, pending the erection of a permanent arsenal in Federal Territory, to continue the manufacture of small arms at Lithgow. Temporary accommodation is to be erected for the new machinery ordered from America to increase the output of rifles.

TILTING CRUCIBLE FURNACE.

CONSTRUCTED BY THE MONOMETER MANUFACTURING COMPANY, LIMITED, ENGINEERS, ASTON, BIRMINGHAM.

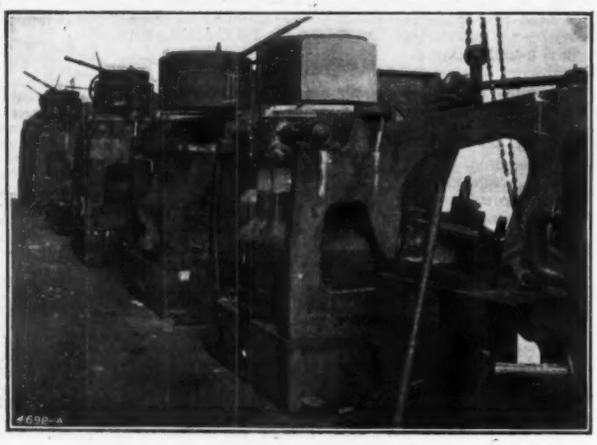


FIG. 1.

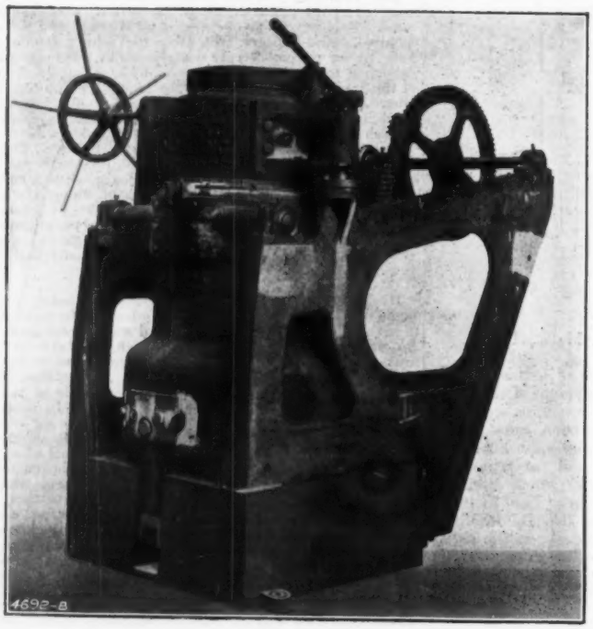


FIG. 2.

Fig. 3.

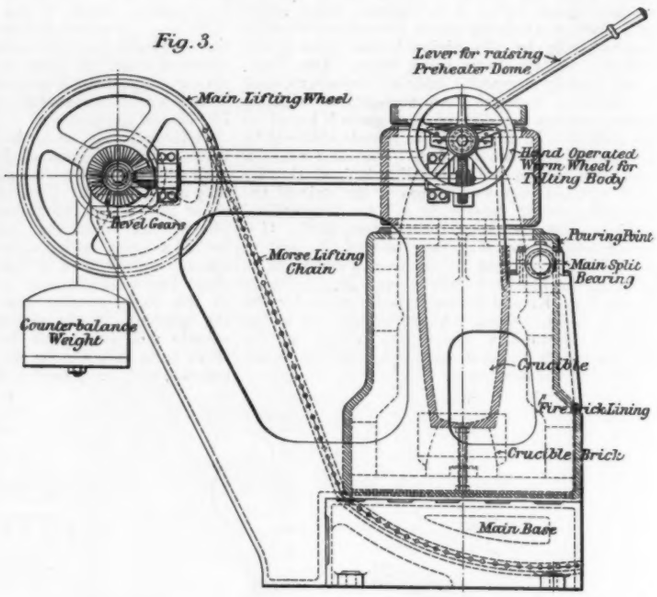
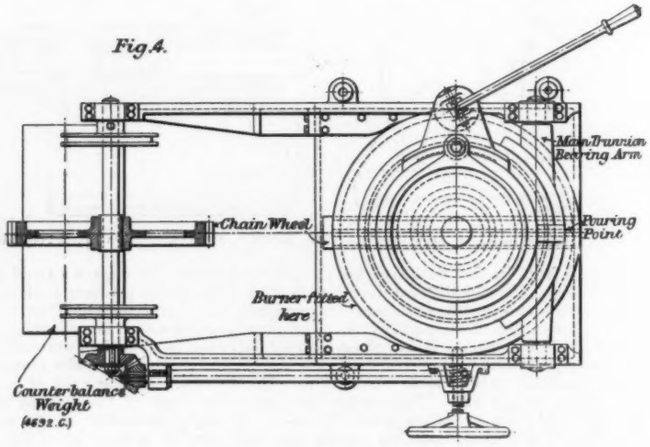


Fig. 4.



THE crucible melting furnaces of the tilting type illustrated on this page are designed primarily for oil-firing, but can also be used with coke and gas. They form part of two batteries of close on 30, which, we understand, the makers are constructing for newly-erected works for melting copper, brass, nickel alloys, &c. The features of particular interest fall under three headings, the combustion-chamber, the method of tilting the furnace, and the constant vertical pouring point. It will be seen from the illustrations that the combustion-chamber is in the form of an annular chamber concentric with, but situated below, the crucible, being connected to the melting-chamber by inclined ducts of adequate area. The object of this combustion-chamber is to delay the escape of the burnt gases, and produce a uniform melting, and also to prevent the intense heat of combustion from concentrating at one point on the crucible, such concentration usually shortening the life of the crucible. The furnace takes standard crucibles without special spouts, and we understand that the crucible life by the monometer system is very materially enhanced. The body is $\frac{1}{4}$ in. thick, of special quality iron of a patented composition, and is extremely rigid.

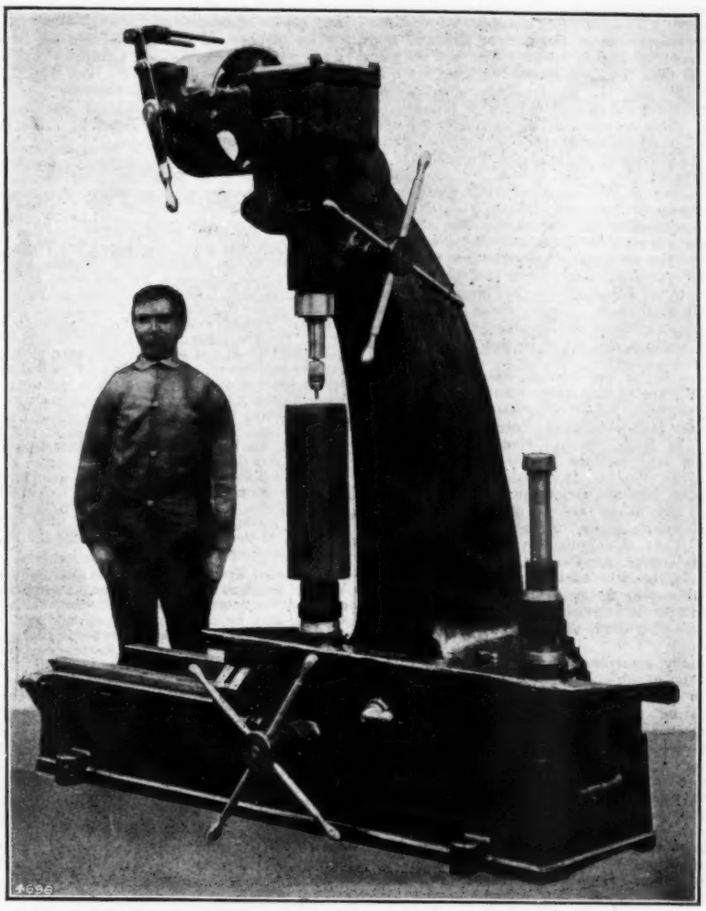
The axis about which the furnace body is turned for the process of pouring is in substantial alignment with the pouring-lip, with the result that the deviation from a strictly vertical plane of the pouring-lip is only about $\frac{1}{8}$ in., and is therefore negligible. The trunnions are adapted to turn in bearings fixed to the main side-frames of the furnace. It may be noted here that the construction and arrangement of the furnace renders the furnace self-contained, and brick-setting unnecessary. The oil-burner directs the oil tangentially into the combustion-chamber, and is attached to the furnace body so as to move therewith. The firing operation can thus be continued during pouring.

The tilting mechanism comprises a transverse tilting-shaft at the back of the furnace, a toothed wheel carried on the shaft, and a high-speed silent chain forming a connecting element of a flexible nature between the furnace body and the toothed wheel. On the bottom of the furnace body, which incidentally is a substantial casting, is formed a quadrantal grooved runway, intended to accommodate the silent chain. The tilting mechanism is completed by a worm and worm-wheel, a pair of bevel-wheels, and an operative hand-wheel. By rotating the hand-wheel, the tilting-shaft is turned, and the silent chain is wound on to the toothed wheel, thereby tilting the body about the trunnions. A point which may be noted is that the toothed wheel on the tilting-shaft is of sufficient diameter to accommodate the silent chain when the furnace is fully tilted, so as to prevent the chain from hanging down; thus there is no possibility of the chain slipping off the wheel. Tilting effort is exerted at the bottom and centrally of the furnace-body, instead of the body being subjected to a twisting strain. The preheater is arranged to prevent access of swarf to the combustion-chamber. A special spigot arrangement prevents damage to the preheater-frame by the hot gases, and confines them to the interior of the furnace. The gas-fired crucible furnace is fitted with a relatively large number of heating units, which distribute the heat of combustion throughout the entire circumference of the furnace, instead of concentrating it at one point, as is customary with gas-fired furnaces using high-pressure gas or air-blast. There are two reservoirs or chambers of comparatively large capacity, each burner having one connection from the gas-chamber and one from the air-chamber. The individual burners can be separately adjusted by taps. The makers of the furnace, which is the subject of patents by Mr. I. H. Hall, managing director of the company, are the Monometer Manufacturing Company, Limited, of Whitehouse-street, Aston, Birmingham.

LONDON SHIPPING, 1916.—The fifth edition of this hand-book has just come to hand from the publishers of the *Journal of Commerce*, Liverpool. It gives a record of the docks, shipping companies, marine insurance authorities, railways, and other commercial and technical organisations associated with the shipping of London, and is issued at the price of 1s., or 1s. 3d. by post.

SHELL-CENTRING MACHINE.

CONSTRUCTED BY MESSRS. WILLIAM ASQUITH, LIMITED, ENGINEERS, HALIFAX.



THE shell-centring machine illustrated on this page is of an extremely simple design, and is supplied for shells of from 4.5-in. to 9.2-in. calibre. It will be noticed that the machine comprises a body of box section securely bolted to a heavy cast-iron base, which is also arranged to receive the jig for holding the shells. This jig is arranged to traverse along the base on carefully-machined slides, and is adjusted by means of a large cross-handle in front, actuating a rack-and-pinion motion. Stops are provided for each of the two positions on the jig, which can be locked in either position. The shells are mounted by a crane on special spring mandrels. The machine is driven by fast-and-loose pulleys, either from an overhead line-shaft or from a jackshaft below. This latter method is the better, as it gives more overhead space for the crane. The spindle is arranged to run at 480 revolutions per minute in ball-bearings, and is also provided with a ball-thrust washer to take the thrust of the cut. The spindle has a down feed of 4 in., operated by a cross-handle at the side of the machine. The machine can be supplied with a special scribing attachment for showing the concentricity of the hole. The makers are Messrs. William Asquith, Limited, Halifax.

TRADE OF NEW SOUTH WALES.—The oversea imports during November were valued at 2,256,738*l.*, and show an increase of 786*l.* as compared with the corresponding month of last year. The total for five months July to November was 14,287,930*l.*, an increase of 1,544,628*l.*, or 12.12 per cent., in comparison with the figures for 1914. The principal articles to show increases were apparel and soft goods, cordage and twines, fish, iron and steel, leather, preserved milk, tea, and tobacco, &c. The oversea exports for November amounted to 3,449,824*l.*, being an increase of 952,621*l.*, or 38.1 per cent., as compared with the corresponding month of last year. For the five months July to November there was an increase of 8,968,007*l.*, or 90.2 per cent., compared with the same period for 1914. Separating merchandise from gold, the exports of the former during the five months increased by 2,013,810*l.*, and the latter by 6,954,197*l.*

THE PHYSICAL SOCIETY OF LONDON.

AT the meeting held on March 10, at the Imperial College of Science, Professor C. Vernon Boys, F.R.S., President, in the chair, a paper entitled "*Experiments Illustrating the Flow of Heat in Conducting Sheets*," was read by Mr. S. Skinner, M.A.

If a sheet of tinned iron be heated locally by means of a Bunsen burner or blow-pipe the tin is melted for a certain distance from the heated region. On allowing the sheet to cool the resolidified tin is separated from the unmelted tin by a very sharp line of demarcation. This line gives us the equi-temperature curve corresponding to the melting-point of tin. By pushing the heating to a greater or less extent a series of such equi-temperature curves can be obtained for a sheet of any particular shape heated at any given point. The cases shown illustrated the flow of heat into a rectangular plate from a heated tongue; into a circular disc from a heated tongue; round the corner of an L-shaped strip and into the vanes of an air-cooled cylinder. The results were shown to be closely analogous to the flow of electricity in similarly-shaped conductors.

Discussion.—Dr. R. S. Willows said a similar method had already been used by Voigt and his students to compare the thermal conductivities of different metals. They employed an organic substance which melted about 41 deg. Cent. and gave a very sharp line on resolidification. Their method of heating was to place the metal strip on a red-hot copper block.

The President asked if the change of colour of mercuric iodide could not be used for this purpose.

Mr. Ezer Griffiths mentioned that if a sheet of steel be heated at the centre by means of a blow-pipe, then, on cooling, a bright circular wave may be seen travelling towards the centre due to recalescence. The converse effect was said to be observed during heating. The heat-indicating paints were the double iodides of copper-mercury (scarlet) and silver-mercury (yellow). Both darkened on heating, the former at 87 deg. Cent. and the latter at 45 deg. Cent., the change being reversible. They could be prepared by adding a solution of $CuSO_4$ or $AgNO_3$ to a solution of KI, redissolving the precipitate and adding a solution of $HgCl_2$. Experiments involving the use of these paints are described in "Light, Visible and Invisible," by Professor S. P. Thompson.

The author said he was glad to hear about Voigt's experiments. He had seen the recalescence experiment mentioned by Mr. Griffiths. One trouble with paints used as heat indicators was that there was usually a considerable lag between the temperatures at which the change took place on heating and on cooling. Moreover, the line of demarcation was not very sharp.

A paper on "*The Absorption of Gases by Quartz Bulbs*," by Dr. R. S. Willows, M.A., and H. Trevelyan George, M.A., was read by the former.

The experiments are a continuation of those of Willows (*Philosophical Magazine*, April, 1901) and Hill (Physical Society, December, 1912) on the absorption of gas which is brought about by electrical discharges. A new quartz bulb does not absorb air, but if it be fed with repeated doses of hydrogen—which are absorbed when an electrodeless discharge is passed—it then becomes very active. If discharges in hydrogen are alternated with those in air the bulb can be made to absorb large quantities of either gas, and the activity with each gradually increases. The authors reject the theory of surface absorption, and, in their own experiments at least, also Swinton's theory that the gas is shot into the walls and held there. It is supposed that chemical actions occur with air, and oxidation products are formed; these are reduced by hydrogen. The process is compared with the formation of the plates in a Planté cell; the absorption of hydrogen corresponding to the charging, and that of air to the discharging of the cell. Attempts to produce the same effects by chemical treatment are partially successful, particularly in fatiguing the bulb so that no further absorption takes place. The conditions under which the primary and secondary hydrogen spectra appear are also described.

Discussion.—Mr. A. Campbell Swinton said he was very much interested in the subject. It was true that most of his experiments were done with tubes having electrodes and there was very considerable heating. Under the bombardment of the cathode particles, the inner surface of the glass may attain a very high temperature for a very short space of time. Sir J. J. Thomson had thought that it might almost become fluid and absorb the gas by ordinary diffusion. Sir J. Larmor, on the other hand, had conceived the molecules of gas to be hammered into the glass like tin tacks by the cathode particles. Some of his experiments had been done with external electrodes of tinfoil tied round the outside of the tube. He had also obtained absorption of helium which was not known to combine chemically with anything.

Dr. Bryan described some experiments he had been making with a vacuum-valve at pressures less than $\frac{1}{1000}$ mm. Normally the electrodeless discharge will not work at this pressure, but it does so when a current is passed through the glower (tungsten filament). Under these circumstances the pressure rises, although, after the valve has been running for some time, the current in the filament when running by itself produces a decrease in pressure.

Dr. Eccles, referring to the failure of gold leaf in certain circumstances to absorb mercury vapour, said that some workers were using silver for this purpose. It seems to have been used successfully for reducing mercury vapour pressure down to, but not beyond, a certain limiting vapour pressure.

Dr. H. S. Allen said that if a tube were coated with silver by spluttering from silver electrodes, the layer so obtained was said to absorb mercury vapour very readily.

Dr. Willows, in reply, said that Mr. Campbell Swinton's results with helium were not conclusive, as it was not certain that they were dealing with the same phenomenon. The discharge in a tube with external electrodes was not an electrodeless discharge at all. There was still cathode-ray bombardment and strong local heating. It would be interesting to see if the experiments with helium could be repeated with a true electrodeless discharge free from any electrostatic effects. He thought Dr. Bryan's results could all be accounted for by gas coming out of the metal itself. He had not used silver to absorb mercury vapour because of the difficulty of getting it free from air. Mr. Harlow, about two years since, showed the Society an experiment similar to the one described by Dr. Bryan.

BEYER, PEACOCK AND CO., LIMITED.—The directors of Beyer, Peacock and Co., Limited, Manchester, return the profits for the past year at 59,319*l.* (increased to 61,264*l.* by a reliquat of 1945*l.* brought forward from 1914), as compared with 114,365*l.* in the previous twelve months. A dividend at the rate of 7½ per cent. per annum is proposed to be paid upon the ordinary shares, leaving 6681*l.* to be carried forward. The serious decline which took place in the profits last year was attributable to Government work, which interrupted the usual business of the company. The great falling-off in locomotive exports was an adverse influence in 1915, especially during the closing months of the year.

"PREPARATIONS FOR PEACE."—In our article on "Preparations for Peace," in our issue of March 10, we referred on page 234 to some figures given by Mr. Harold Cox in his address to the Institution of Civil Engineers, expressing some doubt as to what they included. Mr. Cox now informs us that his statement referred exclusively to exports of home produce. In 1915 our exports of home produce were valued at 385,000,000*l.*; in 1909 they were 378,000,000*l.* In 1903 the value was only 291,000,000*l.*, and Mr. Cox thinks we may assume that the difference between that value and 385,000,000*l.* was not fully accounted for by increase of price. The price of goods exported has not risen, generally speaking, as much as the price of goods imported. The value of our exports in 1915 was greater than in any year previous to 1907.

THE GEARED-TURBINE PROPELLING MACHINERY OF THE FEDERAL LINER "NORTHUMBERLAND"

We conclude this week our series of illustrations of the geared-turbine propelling machinery of the Federal liner Northumberland, supplementing the longitudinal section through the boiler and engine-room, and the transverse sections through the boiler-rooms, published in last week's issue, by reproducing a plan of the boiler and engine-rooms (Fig. 4), a transverse section through the engine-room at the forward bulkhead (Fig. 5), and through it the after end (Fig. 6), all on Plate XXV., accompanying this issue, while on Plates XXVI. and XXVII., and on page 280, there are reproduced drawings of one set of the geared turbines.

While these drawings represent the machinery of the Northumberland, which has been built by Messrs. Swan, Hunter and Wigham Richardson, Limited, Wallsend-on-Tyne, for the Federal Steam Navigation Company, Limited, under the superintendence of Messrs. William Esplen, Son and Swainston, Limited, consulting engineers and naval architects, London and Liverpool, they may also be regarded as a standardised installation of this power—namely, 7700 shaft horse-power—evolved as the result of careful consideration and experience by the Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne, as quite a number of installations almost exactly corresponding to this are now in progress or have been contracted for. In all the company have on hand geared turbines totalling 200,000 horse-power. The firm, under the managing directorship of Mr. Andrew Laing, achieved a high degree of efficiency in the construction of reciprocating engines for merchantmen, largely through the standardising of parts for engines of given power. This was carried to the fullest possible extent, with the result not only of great economy, but rapidity in construction, while the coal consumption and other items of expenditure in sea service were economised as a consequence of the application of experience in sea running to the evolving of the standard designs. Mr. Laing has addressed himself to the same problem in connection with the geared turbine, realising that this type of machinery must sooner rather than later supersede the reciprocating engine for all types of merchant ships; and the details we are able to publish illustrate this standardised system, not so much perhaps in respect to general arrangement as in the exact form of the geared turbines themselves, and will therefore be studied with great interest.

The turbine propelling machinery of the Northumberland, now illustrated, is designed to develop 7700 shaft horse-power in ordinary service conditions, and is capable of attaining 9600 shaft horse-power under trial conditions. The vessel, as shown in Fig. 4, on Plate XXV., is arranged for twin-screw propulsion, the port and starboard lines of shafting being each driven by a set of geared-turbine machinery (see Fig. 6). Each set, as shown in Fig. 8, on Plate XXVII., consists of a high and a low-pressure turbine working in series and coupled to the pinion-shafts by flexible couplings, the pinions being situated one on each side of the gear-wheel, which in turn is coupled direct to the propeller shafting. The astern-going turbines are incorporated in the exhaust end of the low-pressure turbine casings.

The turbines are of the Parsons design, and of the impulse reaction type, an impulse wheel being introduced as the initial stage in the high-pressure ahead and astern turbines, to take the first drop in pressure. The impulse-wheels are followed in each case by the usual reaction stages, while the low-pressure turbines consist entirely of stages of reaction blading. The gearing is of the double helical type, arranged with a spiral angle and depth of tooth which experience has shown to be most suitable. The main gear-wheel is constructed with a cast-steel central portion, to which a heavy steel forged rim is attached. The pinions are of nickel steel. Central bearings are provided for the pinion-shafts to ensure the necessary alignment being preserved.

For the efficient and silent running of this gearing it is essential that the lubrication arrangements should be as perfect as possible, and, as a means to this end, sprayer nozzles distributed at suitable intervals are arranged to spray the oil direct on to the engaging teeth, thereby providing a film of oil between the surfaces in contact. The shaft bearings for the turbines and the gearing are also arranged to work under a system of forced lubrication.

The rotating portions of the turbines (Fig. 10, on page 280), comprising the bodies of the rotors, and the spindle ends, are made entirely from ingot steel forgings. The turbine-casings, which in an ordinary way would have been entirely of cast iron, have in this case been constructed partially in cast steel in order to withstand the degree of superheat of the steam at which it is intended to work these turbines. Those portions of the turbines which are made in cast steel are the steam admission ends of both the high-pressure ahead and astern turbines. Similarly, the material of the blading is partly of copper and partly of the usual brass mixture, the copper sections being fitted to the impulse-wheels and the earlier stages of reaction blading.

The thrust and propeller-shafts are of forged ingot steel, and the propellers are built up with four manganese-bronze blades to each. The propeller-bosses are of cast iron.

The condensers are of the Weir "Uniflux" type, and, as shown in Fig. 9, on page 280, are placed at such a level that the low-pressure turbines drain into them; in this way the accumulation of moisture at the low-pressure end of the turbines is reduced to a minimum. This arrangement also obviates the use of the somewhat objectionable overhead connecting trunk between the low-pressure exhaust and condenser.

Air-pumps of the "Dual" type, as supplied by Messrs. G. and J. Weir, Limited, are fitted in the position shown in Figs. 4 and 6, on Plate XXV., to work in conjunction with the condensers. The condensing plant is capable of maintaining a vacuum of 28½ in. when the machinery is working at full power. Two centrifugal circulating pumps, as shown in Figs. 4 and 6, are fitted for supplying the circulating water to the main condensers. These pumps are each fitted with two single-cylinder double-acting enclosed forced-lubrication engines, and are of Messrs. J. Howden and Co.'s make.

The three boiler-feed pumps, seen in Fig. 5, on Plate XXV., are of the single-cylinder direct-acting vertical type, each pump being capable of delivering the necessary feed-water under ordinary service conditions. The feed-pumps deliver the feed-water through one large surface feed-water heater of the multiflow type (Fig. 5). It is designed to utilise the exhaust steam from the various auxiliaries. The feed-pumps and feed-heater are all of Messrs. G. and J. Weir's well-known make. A feed-water filter of the "Cascade" type, as supplied by the Contraflo Condenser and Kinetic Air-Pump Company, Limited, is fitted (Fig. 5), the filter-tank being provided with the necessary float-gear for controlling the feed-pumps. The air-pumps are arranged to deliver the feed-water to this filter-tank, and the feed-pumps to draw therefrom,

An auxiliary condenser of the ordinary design is fitted and is capable of dealing with the exhaust steam from the whole of the auxiliary pumps, &c., electric-lighting plant, winches, and deck fittings. This condenser is of the non-vacuum type and arranged to drain to the filter-tank.

In connection with the forced-lubrication system, there are fitted two single-cylinder direct-acting vertical pumps of Messrs. G. and J. Weir's make. These pumps draw from the oil-drain tanks situated in the double bottom of the ship, and deliver through a multitubular oil-cooler either to gravitation tanks, or direct to the gearing and turbine shaft bearings, the oil after use finally draining back to the tanks in the double bottom.

A duplex pump of the vertical type, of Messrs. Lamont and Co.'s make, is fitted for supplying circulating water to the oil-cooler.

Other auxiliary machinery fitted in the vessel by the machinery contractors, and shown in the sections and plans on Plate XXV., comprises the following:—A service donkey for general purposes of the single-cylinder direct-acting type, of Messrs. G. and J. Weir's make, and a large ballast pump and a sanitary pump, both of the vertical duplex type and of Messrs. Lamont and Co.'s make. There is also a bilge-pump worked from each gear-wheel shaft. The evaporating plant fitted by the machinery contractors consists of two evaporators supplied by Messrs. G. and J. Weir. The evaporators are of the vertical merchant-service type, each capable of evaporating 30 tons of water per day of 24 hours, when supplied with steam direct from the boilers. For feeding the evaporators a vertical single-cylinder pump of Messrs. Lamont and Co.'s make is provided.

The boilers, which have also been constructed by the Wallsend Slipway and Engineering Company, Limited, are of the single-ended type, eight in number, 16 ft. 6 in. diameter and 12 ft. long, and constructed for a working pressure of 190 lb. per sq. in.

Six of the boilers are fitted with Schmidt's superheaters, the arrangement of which is such that the degree of superheat is limited to 125 deg. Fahr. at the turbines. The boilers are grouped in one boiler-room, with two firing spaces; six of the boilers are placed three abreast, and back to back, the remaining two boilers being placed forward of the others. One large elliptical-shaped chimney is provided, having an outer casing. The total height of the chimney above the grate is about 102 ft. The position in the ship of the boilers is shown in Fig. 1, on Plate XXIV., and Figs. 2 and 3, on page 256 of our issue of the 17th inst., and on the plan on Plate XXV., in this issue.

The boilers are designed to work under the Howden system of forced draught, provision being made for this in accordance with drawings supplied by Messrs. J. Howden and Co., Limited, as shown in Figs. 1 to 4. For supplying the air to the system two large fans are fitted. Each fan is of the double-inlet type and driven direct by one single-cylinder double-acting enclosed forced-lubrication engine. The fan and engine have been supplied by Messrs. Howden, the engines being duplicates of those fitted to drive the centrifugal circulating pumps. The fans are arranged to assist in the ventilation of the boiler-room and engine-room.

The disposal of the ashes from the boiler-room is dealt with by two Railton Campbell and Crawford's patent ash-hoists fitted with self-tipping buckets, arranged to deliver into ash-shoots.

The whole of the machinery has been built to Lloyd's requirements and Board of Trade regulations for passenger certificate.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—The position in the pig-iron market was quite unchanged last Wednesday afternoon; as in the morning, no business was done, and sellers' prices remained on the same level as at the morning session. Thursday showed no improvement so far as business was concerned, no transactions taking place, although the cash rate for Cleveland warrants was firmer at 89s. per ton sellers, this advance being made in the morning. Complete idleness continued on Friday morning, when, however, cash sellers were quoted 90s. per ton, this figure dropping in the afternoon to 89s. On Monday forenoon one Cleveland warrant was dealt in, the price realised being 88s. per ton, sellers being quoted at the close at 89s. This figure fell to 88s. 6d. per ton at the afternoon market, but no transactions took place. No business was done yesterday, but a slight advance was made to sellers' prices, 88s. 9d. being quoted at the close of the forenoon session, this dropping to 88s. 6d. again in the afternoon. This morning showed no improvement, no dealings taking place, while sellers' cash quotations at the close of the market were nominally 88s. 6d. per ton, and the settlement price 88s. 3d.

Scotch Steel Trade.—So far as the steel industry in the West of Scotland is concerned, the situation remains unchanged, the enormous output of war work constituting a record day by day, while the energy and activity of the workers are almost entirely concentrated upon the requirements of the Government. For war purposes, heavier sections are not greatly in demand; but light sections of all classes—bars, sheets, plates—cannot be turned out in sufficient quantity to meet the exigencies of the case, and this in spite of the enormous output. Of course, no effort to increase this is left untried, and the utmost activity prevails in every steel-making establishment. An exceptional demand, too, is being made by the French Government for thin steel sheets for the purpose of bomb-making. The system of classification of orders now in progress at all controlled establishments is certain to prove most helpful, and as the bulk of the work in and around Glasgow comes under Class A, which represents all orders undertaken on behalf of our own or the Allies' Governments, it will be seen what a very small output can be put through on general mercantile account. This is the more unfortunate when the necessity of building up and retaining a good foreign connection after the war is taken into consideration. Meantime, however, the termination of the war is of the greatest importance, so that munitions and the various other requirements must come first. The labour, freight, and transport difficulties continue increasingly to hamper all classes of trade, more particularly of export. Prices still keep strong; boiler-plates have advanced to 14*l.* 7s. 6d. or 14*l.* 10s. per ton, ship-plates are 13*l.* to 13*l.* 10s., and angles are 13*l.* 5s. to 13*l.* 15s.—all less the customary 2½ per cent. for prompt delivery.

Malleable-Iron Trade.—Little if any change has taken place in regard to the conditions ruling in the malleable-iron trade. Makers have as many orders as they can conveniently cope with, considering the difficulty of obtaining workers of any kind, more particularly skilled puddlers, who are unmistakably a race apart. Notwithstanding this, however, the output continues on a most extensive scale. Indications now point to a maximum price being fixed by the Ministry of Munitions for iron bars, basing this on the level of 13*l.* net f.o.t. works for "Crown" bars. Considering the high and uncertain cost of pig-iron, this may not be quite such an easy task as it seems at first sight, but the Government seems determined that all finished material must come under the restriction order. "Crown" bars meantime keep steady at about 14*l.* per ton, less 5 per cent. discount for prompt delivery.

Scotch Pig-Iron Trade.—Rumour is still busy with the pig-iron trade, and it is now asserted that before very long ordinary foundry iron will be subject to the same restrictions as have recently been put upon hematite by the Government, and that its export can only be effected by licence. Locally the demand for hematite by the steel works engaged upon the production of munitions is very great, and strong prices hold; but the difficulty experienced in obtaining licences for its export is having a rather serious effect upon this branch of the trade. The project for limiting the maximum rate to 6*l.* 2s. 6d. is still held in abeyance, as producers will not sell at this price, claiming still the current quotation of 7*l.* 5s. per ton. Prices continue high, and the large volume of pig-iron being produced is a very marked feature of the industry, the cost of the inward ore and the continued heavy demand both contributing to this. The following are the current quotations for makers' (No. 1) iron:—Summerlee and Langloan, 125s. per ton; Clyde, Calder, and Gartsherrie, 127s. 6d. (all shipped at Glasgow);

Eglinton, 120s.; Glengarnock, 125s. (both at Ardrossan); Dalmellington, 122s. (at Ayr).

Sale of Clyde Shipyard.—The Greenock and Grangemouth Dockyard Company, Limited, have just completed the purchase of the extensive shipbuilding yard at Whiteinch, for many years owned and worked by Messrs. John Reid and Co., Limited. Although the yard has been shut down during the past five or six years, both plant and equipment have been kept in the best possible condition, and when necessary alterations, &c., are made work will be resumed.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The demand for all qualities of manufacturing fuel remains very heavy and supplies are not sufficiently large to meet them. Consumption in the Sheffield works is gradually increasing, and this accentuates the position. Merchants are unable to keep all the works fully supplied. In some instances house coal is being adopted to make up the shortage of steam coal for works. Merchants are convinced that the present difficult position is not due to an actual shortage at the pits, but to irregular workings of colliers in the unfavourable weather, and to the bad railway facilities. Rail-borne traffic is now fully ten times as long on the journey as on normal occasions. The railway authorities have promised improvements, but the position with regard to empty wagons is still chronic, and they congest the sidings. Even collieries which are fulfilling urgent Government orders suffer from the dislocation, and reports of long delays are common. The position cannot be relieved by carting, for there is a dearth of available road-travelling vehicles owing to the enlistment of the drivers. Shipment for French and Italian ports continue at a good figure, but with neutral countries little business is being done. Swedish steel-makers are still offering tempting prices for Yorkshire coal. It is expected that the stringent export regulations may be relaxed to allow of steel being received in return. Gas-fuels are being freely supplied for home works on contract account. There are no new developments in the house-coal trade. Quotations:—Best branch hand-picked, 20s. 6d. to 21s. 6d.; Barnsley best Silkstones, 17s. 6d. to 18s. 6d.; Derbyshire best brights, 17s. 6d. to 18s. 6d.; Derbyshire house, 16s. to 17s.; best large nuts, 15s. 6d. to 16s. 6d.; small nuts, 15s. 6d.; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 12s. to 13s.; seconds, 10s. 6d. to 11s. 6d.; smalls, 8s. to 9s.

Iron and Steel.—The feature of the week has been the remarkable change with regard to the price of East Coast hematite. This brand has long been marked fully 10s. to 12s. dearer than West Coast, which is quoted at 130s., plus cost of carriage. The Government have now taken strong action, and a maximum of 122s. 6d., free on truck, has been fixed for East Coast. The sliding-scale arrangement has also been abolished, but makers have been offered something in the shape of a safeguard by the Government against any fluctuations in the price of ore and of freights. It is not expected that this drastic action will have any immediate effect upon the market, as consumers have before now placed orders for many months ahead at the old rates. The Government maximum does not apply to the export trade, and what tonnage is available finds ready purchasers in France and Italy at 145s. Some relief is anticipated in the position of the billet consumers by the promise of Government action with regard to the Swedish supplies. Representations have been made that there should be some relaxation of the severe policy of export licences of coal to Scandinavia, so as to induce Swedish steel-makers to augment their billet consignments. Swedish steel billets, rods, and bar iron are greatly needed. Prices are still abnormally high. The supply of tungsten ore is now assuming excellent proportions. This is largely due to the completion of the new works at Widnes, which have been erected on the initiative of Sheffield manufacturers. Widnes now provides Sheffield works with more ore than the whole pre-war consumption of the city, and it is reputed to be infinitely superior to the German standard. A contract for the supply of a hot-well tank and piping has been placed with Messrs. Newton, Chambers and Co. by the Manchester Corporation. Tramway axles, for delivery during the year ending March 31, 1917, have been ordered by the Salford Corporation from Messrs. W. T. Ritchie and Co. Difficulties of railway transport are embarrassing steel-makers, whose warehouses are severely congested by inability to obtain prompt service for removal of goods. The cutlery trade is not in a happy position. All remaining staffs are engaged on Government contracts and export trade, with the result that the home market is being seriously neglected. This has arisen through non-reservation of workmen engaged in the home trade. The new annual contracts for naval officers' messes are now being considered. The latest overseas orders are for steel, files, tools, saws, sickles, and springs.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The belief that further embargo will be placed on Cleveland pig-iron shipments to neutral countries has checked buying. Continental customers are very keen to place orders, and many of them continue to instruct their agents to buy on the best terms possible; but with prospects of having iron left on his hands that he may have to sell at a loss, the merchant exporter is acting with extreme caution, and is buying for prompt delivery only. The export quotation of No. 3 Cleveland pig-iron is 90s. f.o.b., and No. 1 is put at some 4s. above that figure. For home consumption No. 3, No. 4 foundry, and No. 4 forge all stand at the fixed maximum of 82s. 6d.

Hematite Iron.—The East Coast hematite branch of the staple industry presents no new feature of moment. Business is practically at a standstill, as there is no iron available for sale for supply before July, and makers are not disposed to commit themselves further ahead. Efforts of home consumers to buy Nos. 1, 2, and 3 over the second half of the year, at the fixed maximum for home use of 122s. 6d., are meeting with no success. For export, the forward quotation of mixed numbers remains at 140s.

Stocks and Shipments of Pig-Iron.—Practically the only stock of pig-iron is the 64,874 tons of Cleveland in the public warrant stores, and to meet current needs it is being drawn upon this month at the rate of 1000 tons per working day. The stock is composed of 62,546 tons of No. 3 quality, and 2328 tons of other kinds of iron deliverable as standard. So far this month 17,860 tons of No. 3, and 457 tons of standard iron, a total of 18,317 tons, have been taken from the stores. Shipments of pig-iron from the port of Middlesbrough are, under the prevailing conditions, on a satisfactory scale. To date this month they average 1660 tons per working day, the total despatches reaching 31,530 tons, as compared with loadings amounting to 30,546 tons, or a daily average of 1608 tons to the same date last month, and clearances of only 7140 tons, or an average of 381 tons per working day.

Coke.—Very little new is ascertainable concerning coke. Local requirements are fairly heavy, and business is stated to be still passing at the fixed maximum for home consumption of 28s. at the ovens for average blast-furnace kinds, and up to 30s. 6d. at the ovens for qualities low in phosphorus.

Foreign Ore.—The position in foreign ore is peculiar. Buyers at present market rates are understood to be entitled to a payment from the Government of the difference between ruling quotations and the arranged maximum. There is little business doing. Though a sale has been recorded on lower terms, market quotations are still based on 43s. ex-ship Tees for Rubio of 50 per cent. quality. Freights Bilbao-Middlesbrough still stand firm at 26s. 6d., but the Government intend to lower them by eliminating competition for boats. Imports of foreign ore to the Tees to date this month amount to 73,958 tons.

Manufactured Iron and Steel.—There are now very numerous ordinary commercial inquiries in the market for finished iron and steel, but manufacturers pay little or no attention to them, as they are still fully occupied with Government work. Principal market quotations stand:—Common iron bars, 13*l.* 10s.; best bars, 13*l.* 17s. 6d.; best best bars, 14*l.* 5s.; packing iron (parallel), 10*l.*; packing iron (tapered), 11*l.* 15s.; iron ship-plates, 11*l.* 10s.; iron ship-angles, 13*l.* 10s.; iron ship-rivets, 16*l.*; steel ship-plates, 11*l.* 10s.; steel ship-angles, 11*l.* 2s. 6d.; steel joists, 11*l.* 2s. 6d.; steel strip, 13*l.* 10s.; steel hoops, 14*l.*; and heavy steel rails, 10*l.* 17s. 6d.—rails net f.o.b., steel ship-building material and steel joists net at works, and all other descriptions less 2½ per cent. discount.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Tonnage arrivals have not been very satisfactory, but there are hopes of an improvement following chartering at greatly increased rates; colliery owners are also expecting to keep pits working fully for the next week or two. Under these circumstances, there has been less disposition to make concessions in regard to prices, although reductions are still made for immediate loading. Smalls have shown rather more firmness. The best Admiralty large steam coal has been, to some extent, nominal; secondary qualities have made 30s. to 31s. per ton; best bunker smalls, 17s. to 17s. 6d.; and cargo smalls, 11s. to 14s. per ton. Current quotations for bituminous coal have been as follow:—Best households, 23s. to 24s.; good households, 21s. to 22s.; No. 2 Rhondda large, 25s. to 26s.; and No. 2 smalls, 15s. 6d. to 16s. 6d. per ton. The latest quotation for patent fuel has been 35s. to 37s. 6d. per ton. Special foundry coke has made 50s. to 52s. 6d. per ton; good foundry coke, 47s. 6d. to 50s.; and furnace coke, 35s. to 40s. per ton. As regards iron ore, Rubio has been quoted at 39s. to 40s. per ton. upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Western Trade Matters.—Lord Rhondda has now been elected chairman of the Celtic Collieries, Limited. The reorganisation of the board has also been completed.—Further advances in freight rates have occurred at Cardiff; the rise in the case of Alexandria was 2s. 6d. per ton, the rate being carried to 107s. 6d. per ton, while in July, 1914, the last month before the outbreak of the war, it was barely 7s. per ton.—It has been agreed that there shall be no strikes in the South Wales coal-mining districts during the war; any differences which may arise and which cannot be settled are to be referred to the arbitrament of the Chief Industrial Commissioner (Sir G. Askwith).—Freight rates from Cardiff to Genoa have advanced to 84s. per ton for Cardiff and Newport loadings and 95s. per ton for Swansea loading.—The shareholders in the Bennett Steamship Company are to receive a dividend and bonus of 20 per cent. for 1915; the profits for the year were 38,568*l.*, to which must be added 2236*l.*, brought forward from 1914; after payment of the proposed dividend a balance of 23,944*l.* is to be carried forward subject to excess profits duty and income tax.—Lord Rhondda, presiding at the annual meeting of the Imperial Navigation Coal Company, stated that both the company's pits had been deepened; they were now sunk to a depth of 700 yards, as they should have been in the first instance, and they were now among the deepest in South Wales. Lord Rhondda added that the coal raised was of fair quality; there was also plenty of it.—There is a considerable shortage of house coal at Swansea: a number of merchants have been without coal for several days. The present state of affairs is attributed to shipments of coal abroad at higher prices; the present strain is expected, however, to subside with the advent of summer.—Messrs. Elliott and Jeffrey who, in addition to works at Cardiff Docks, own the Windsor Slipway, have decided to establish ship-repairing works at Barry, where they have acquired the workshops of Messrs. Mordey, Carney and Co., Limited; plant of a modern type is to be introduced.—A decrease of 2,700,000 tons in the year's production was reported at the annual meeting of the Monmouthshire and South Wales Coal-Owners' Association. The falling off was attributed to the diversion of so much industrial labour to military pursuits. The output for the ensuing year is estimated at 44,046,428 tons—viz.: Cardiff district, 29,411,149 tons; Newport district, 9,873,722 tons; and Swansea district, 4,761,557 tons. Mr. W. H. Manton has been elected President of the Association for the ensuing year.—The Bedwas Colliery Company, Limited, has provided for arrears of preference dividends to the close of 1915.—The directors of Baldwin's, Limited, recommend an interim dividend of 2½ per cent., payable April 7. Dividends are also recommended as follows by the directors of the Pontypool Gas and Water Company: 12*l.* shares and A shares at the rate of 9½ per cent. per annum, and B, C and D shares at the rate of 6 per cent. per annum. For the whole of the past financial year the 12*l.* and A shares will accordingly receive 7½ per cent. per annum, and the B, C and D shares 5½ per cent. per annum.—A suspension of sailings has occurred in the Great Western Railway Irish service. The 8.30 p.m. express ex-Paddington is not to run until further orders.—An advance of 12s. 6d. per ton has occurred in River Plate freights at Cardiff; this carries freights to 70s. per ton as compared with 14s. 10d. per ton just before the outbreak of the war; practically the whole of the advances have been secured by neutral owners.—Including 1887*l.* brought forward, the net profits of Turnbull Scott shipping last year were 66,916*l.*; after allocation of 6000*l.* to survey account, 12,000*l.* to general reserve, and 35,000*l.* to excess profits suspense account, a dividend of 25 per cent. is recommended for the past twelve months, a final balance of 2830*l.* being carried forward.—Tin-plates have continued to rise, but the trade is not considered to be in a healthy condition, and the labour question is occasioning considerable uneasiness.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, March 8.

STEEL-buying continues at an unprecedented rate; orders aggregating 4,000,000 tons, valued at 240,000,000 dols., have been placed since January 1. The volume of business in sight is enormous. Railroad equipment, since January 1, and steamships reached nearly 1,000,000 tons; orders for cars and locomotives since that date aggregate 30,000,000 dols. in value; shipyards have taken orders since that time for 43 vessels, making a total now under construction of 334 ships, of which 275 are for the mercantile marine and 59 for the United States Government. About 40 per cent. of export steel sales have been for the manufacturers of munitions in Europe; besides this, large sales have been made for the home manufacturers of shrapnel and high-explosive shells for European destinations. February sales of war munitions are estimated at 300,000 tons for direct export, and 600,000 tons since January 1. Total shipments abroad last year amounted 5,513,453 tons, an increase of 25 per cent. over the previous year. Sales of pig-iron for the past two weeks were nearly 400,000 tons; for February, over 800,000 tons; and since January 1, 1,250,000 tons. Large orders have been placed for locomotives and cars for remote future delivery.

For three or four years the railroads have been very backward in ordering equipment and rolling-stock, and are now making up for lost time. The greatest urgency prevails for locomotives of large size. The Southern Pacific have just placed orders for equipment valued at 6,000,000 dols.; transportation facilities all over the country are seriously short of actual necessities. A serious condition confronts the country as to supplies and equipment. It would be easier to borrow trouble in advance and make all sorts of gloomy predictions. Two or three overwhelming Allied victories would probably lessen the urgency for munition orders for distant delivery.

MANUFACTURE OF TIN PLATES IN NORWAY.—Consul-General L. Haldeman Dennison, of Christiania, says the *Anglo-Norwegian Trade Journal*, has reported that the fish-canners of Stavenger, who have been trying to become independent of foreign countries for their supply of tin plate, have been successful in their attempts to secure sufficient capital for the erection of rolling-mills in their city. As more than 30,000 tons of tin plate are used annually in the Stavenger district alone, the plans for the new mills provide for a yearly production of at least 30,000 tons. This enterprise will cost more than 200,000*l.*, and will employ 400 to 500 men. The electric machinery to be installed will generate 1600 horse-power, but the maximum production will probably not be reached for three or four years. No attempt will be made to begin construction until after the close of the European war, because of the difficulty in obtaining the raw material.

ONE SET OF GEARED TURBINES OF THE FEDERAL LINER "NORTHUMBERLAND."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Description, see Page* 278.)

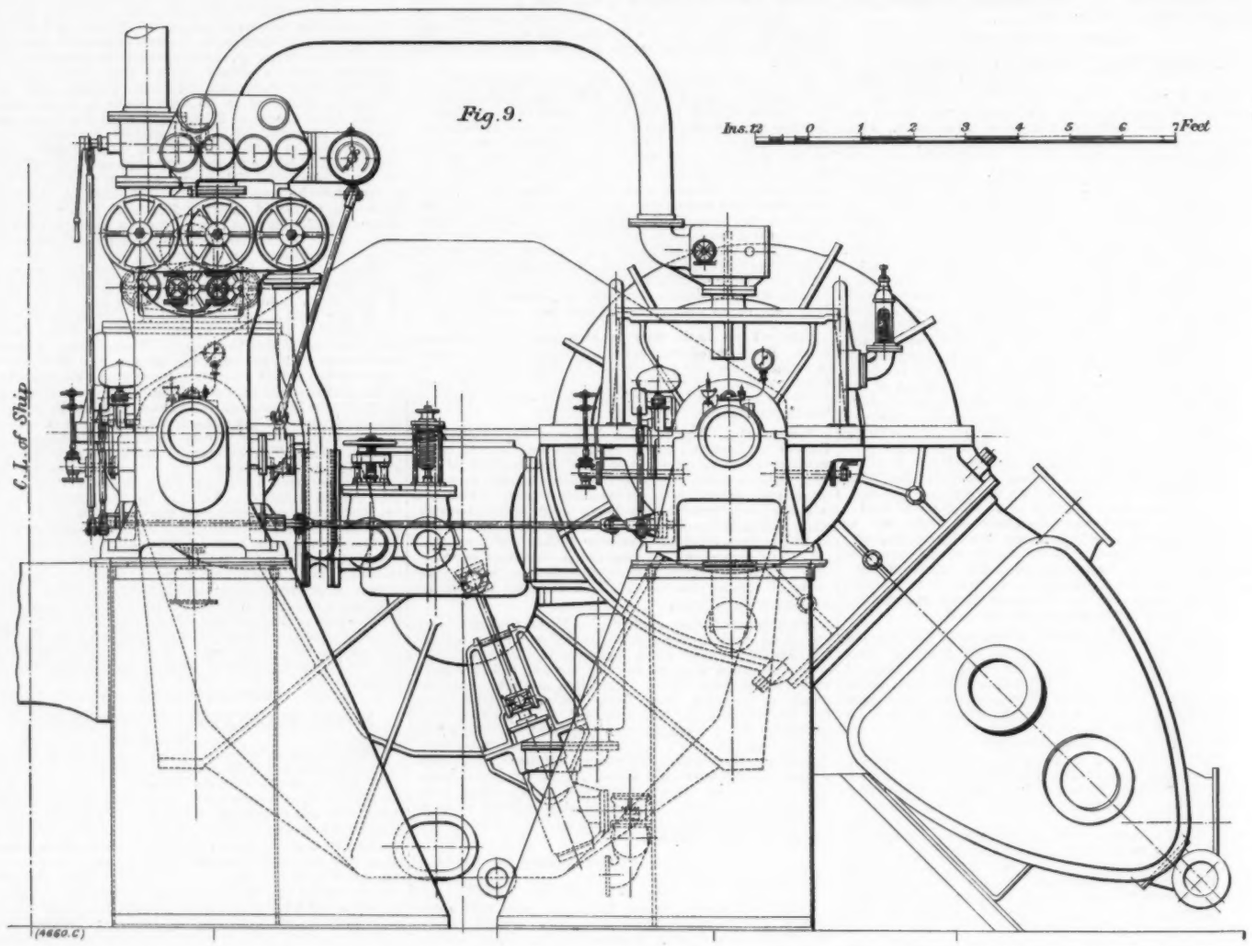


FIG. 9. END VIEW OF TURBINE SET SHOWING MANŒUVRING-GEAR.

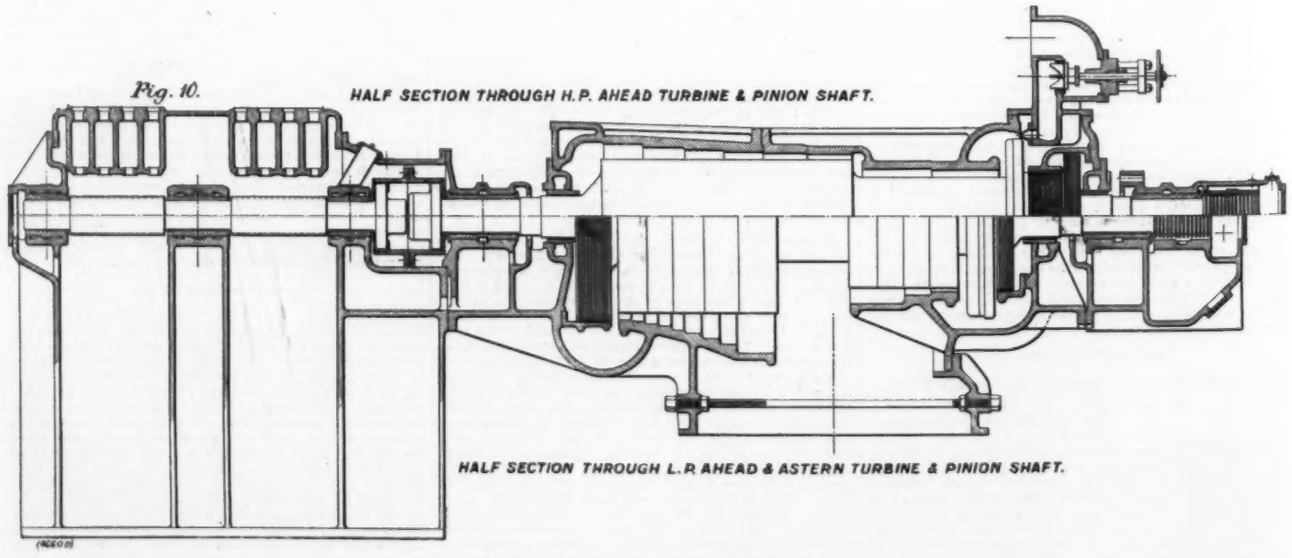


FIG. 10. SECTIONS THROUGH TURBINES.

ONE SET OF GEARED TURBINES OF THE FEDERAL LINER "NORTHUMBERLAND."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Description, see Page 278.*)

Fig. 7.

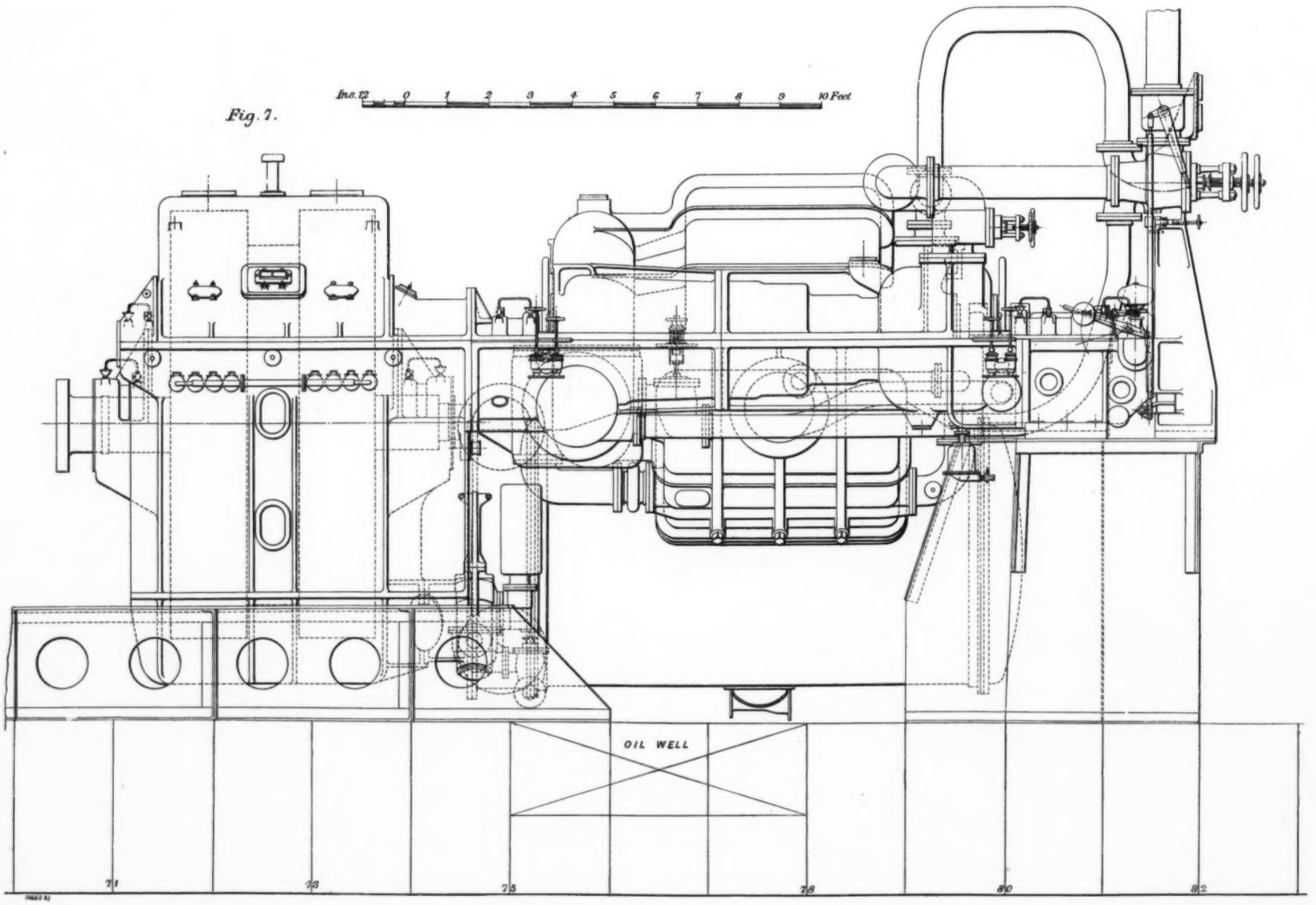


FIG. 7. ELEVATION OF TURBINES, GEAR-CASE, AND MANŒUVRING-GEAR.

(*To Face Page 278.*)

GENERAL ARRANGEMENT OF THE GEARED-TURBINE PROPELLING

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINE

(For Description, see Page

Fig. 5.

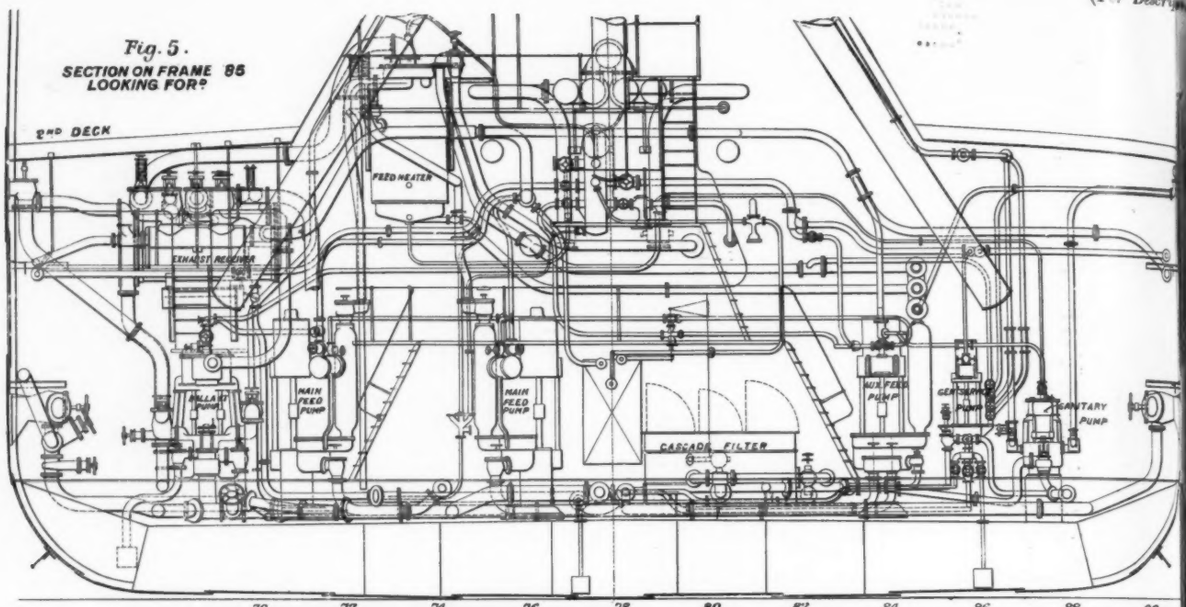
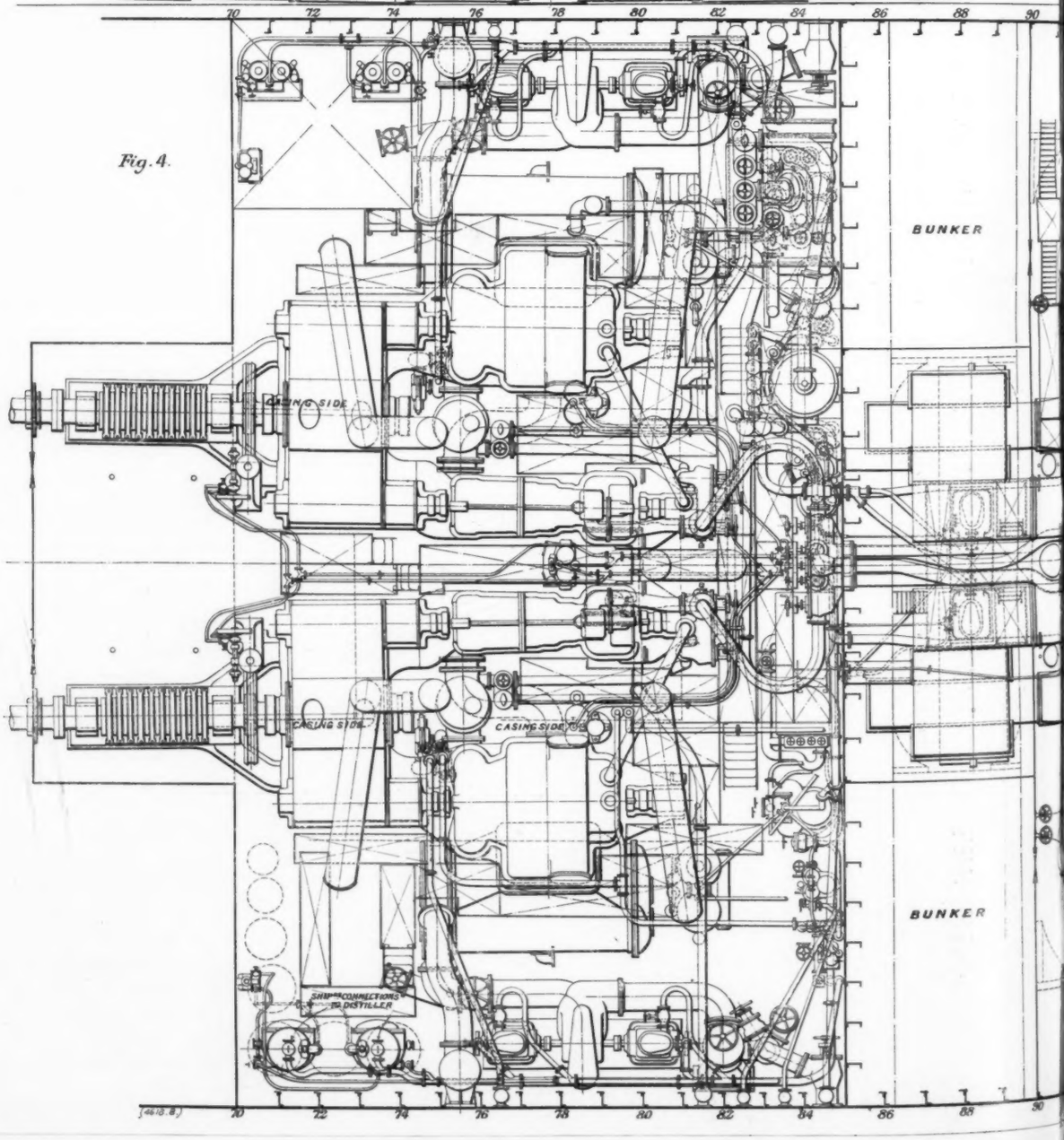


Fig. 4.

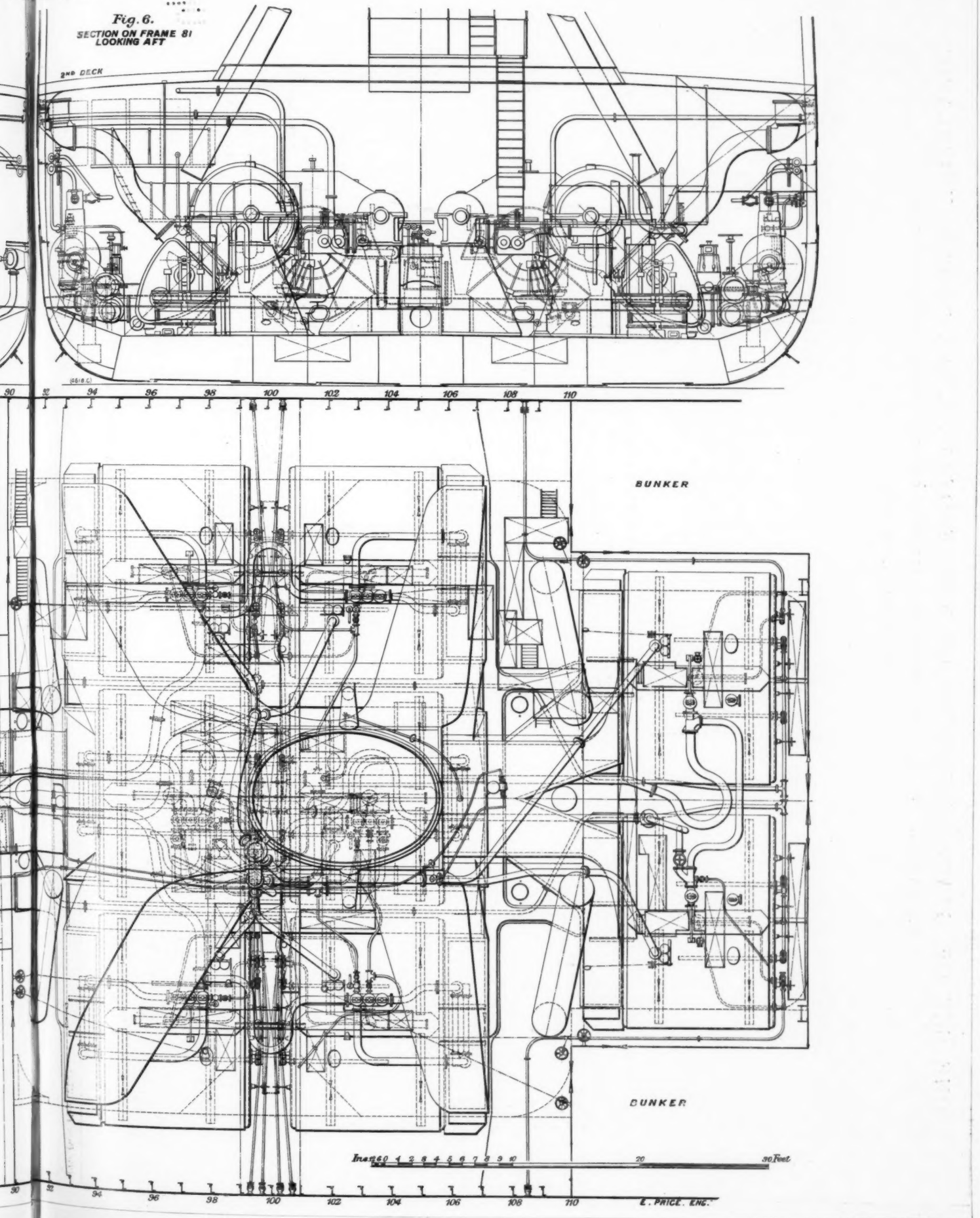


ELLING MACHINERY OF THE FEDERAL LINER "NORTHUMBERLAND."

AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(For Description, see Page 278.)

Fig. 6.
SECTION ON FRAME 81
LOOKING AFT



ONE SET OF GEARED TURBINES OF THE FEDERAL LINER "NORTHUMBERLAND."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Description, see Page* 278.)

Fig. 8.

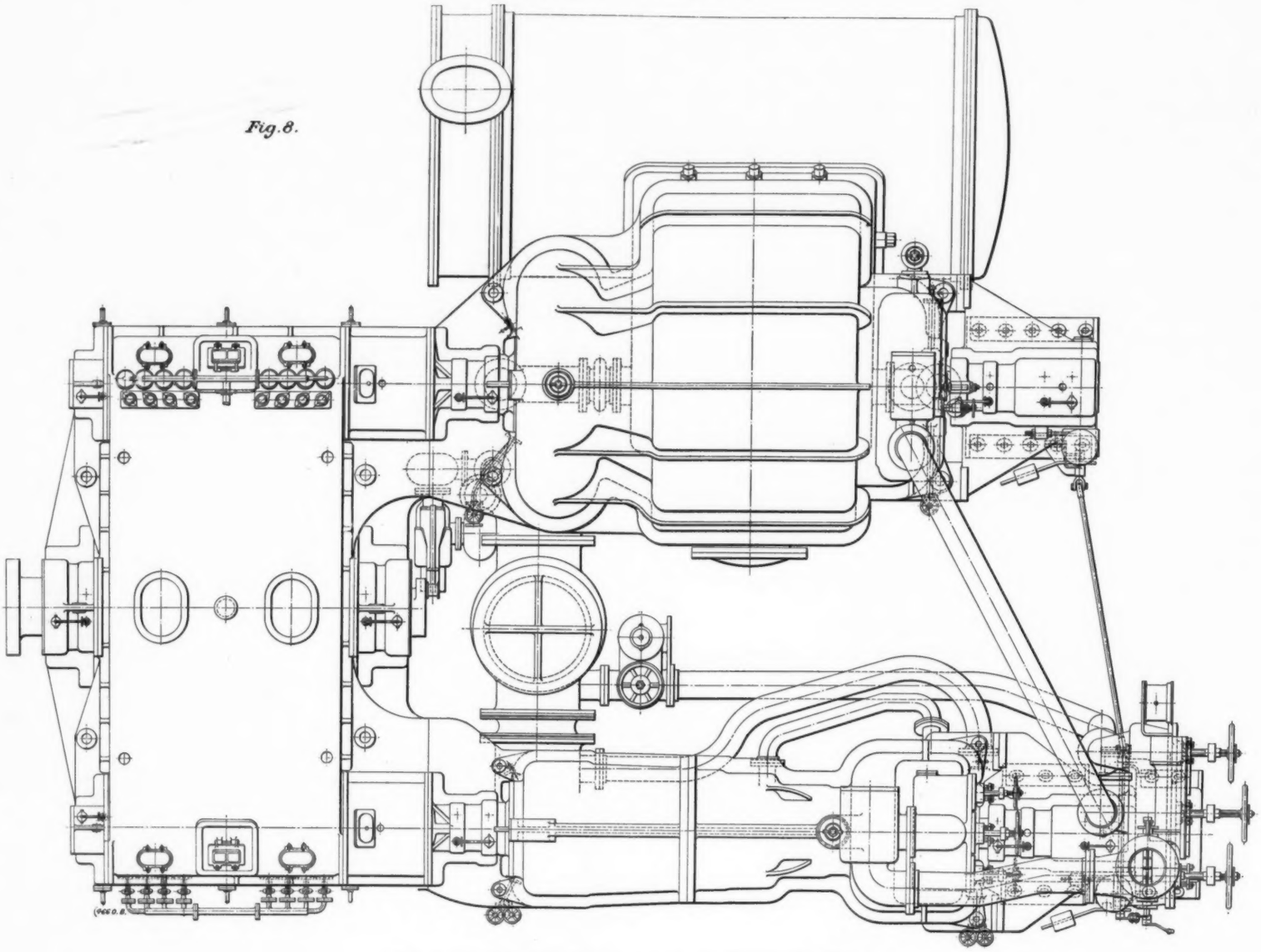


FIG. 8. PLAN OF TURBINES, GEAR-CASE, AND MANŒUVRING-GEAR.

(*To Face Page* 279.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

S.S. "PERSIA" AND S.S. "MALOJA."

The Publisher desires to notify subscribers to "ENGINEERING" in the East who did not receive their copies of "ENGINEERING" of the issues of December 17, 1915, and February 25, 1916, that they may have gone down with the mails in the S.S. "Persia" and S.S. "Maloja." A few copies are still in stock of each of these issues, and may be secured at the ordinary rates, plus postage.

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With One Two-Page Plate and Two One-Page Plates of the GENERAL ARRANGEMENT OF THE GEARED-TURBINE PROPELLING MACHINERY OF THE FEDERAL LINER "NORTHUMBERLAND."

NOTICES OF MEETINGS.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, March 25, at 7.15 p.m., at the Institute, Wolverhampton-street, Dudley. Mr. J. E. Fletcher, M.I. Mech. E., President, will read a paper on "Blast-Furnace Working and the Function of Slags."

THE ROYAL SOCIETY OF ARTS.—Monday, March 27, at 4.30 p.m. Fothergill lecture. "Surveying: Past and Present," by Mr. E. A. Reeves, F.R.A.S., F.R.G.S., Map Curator and Instructor in Surveying to the Royal Geographical Society (Lecture I.). Tuesday, March 28, at 4.30 p.m. Colonial Section. "Next Steps in Empire Partnership," by Mr. Percy Hurd, Joint Author of "The New Empire Partnership: Defence, Commerce, Policy." Dr. Dugald Clerk, F.R.S., Chairman of the Council of the Society, will preside. Wednesday, March 29, at 4.30 p.m. Ordinary meeting. "Pan-German Aspirations in the Near East," by Mr. R. W. Seton-Watson, D.Litt. Sir Edward Pears will preside.

THE ROYAL SANITARY INSTITUTE.—Tuesday, March 28, at 4.15 p.m., at 90, Buckingham Palace-road, when a discussion will take place on "Made-Down and Tenemented Houses," to be opened by Mr. G. M. Pettit, Chief Sanitary Inspector, Kensington. The chair will be taken by Mr. A. Wynter Blyth, M.R.C.S., L.S.A., Registrar. Friday, March 31, at 3.30 p.m., at the Physics Theatre, University, Liverpool, when a discussion will take place on "Tubercular Diseases of Children and Milk Supply," to be opened by Professor J. Martin Beattie, M.A., M.D. The chair will be taken by Colonel J. Lane Notter, M.A., M.D., R.A.M.C., Treasurer of the Institute.

THE INSTITUTE OF METALS.—Wednesday, March 29, at 4 p.m. and 8 p.m., in the Rooms of the Chemical Society, Burlington House, Piccadilly, W. The report of the Council will be presented, and the results of the ballots for the Council for 1916 and for the election of new members will be declared. The Presidential address will be delivered. A selection of papers will be read and discussed. The following is a list of the papers in the order in which they are expected to be submitted:—(1) "Third Report to the Corrosion Committee," by Messrs. W. E. Gibbs, M.Sc., R. H. Smith, and G. D. Bengough, D.Sc., M.A. (2) "The Electrolytic Method of Preventing Corrosion," by Mr. Elliott Cumberland. (3) "Note on Some Tin-Aluminium-Copper Alloys," by Professor A. A. Read, D.Met., and Mr. R. H. Greaves, M.Sc. (4) "Notes on the Analysis of Aluminium and its Alloys," by Mr. W. H. Withey, B.A. (5) "The Annealing of Nickel Silver," by Mr. F. C. Thompson, M.Met., B.Sc. (6) "Electric Furnaces as Applied to Non-Ferrous Metallurgy," by Professor A. Stansfield, D.Sc., A.R.S.M. (7) "Transformations in Alloys of Gold and Copper," by Dr. N. S. Kurnakow, S. Zemczuzny, and M. Zasedatelev.

THE INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.—Wednesday, March 29, at 7.45 p.m. Annual general meeting.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 31, at 5.30 p.m. A discourse will be delivered by Professor A. Fowler, F.R.S., Sec. R.A.S. The subject is "The Spectra of Hydrogen and Helium." Afternoon lectures next week at 3 o'clock. Tuesday, March 28. Professor F. Keeble, M.A., Sc.D., F.R.S., Director, Royal Horticultural Society's Gardens, Wisley, on "Modern Horticulture: Plants and the Seasons (Seasonal Rhythm)" (Lecture I.). Thursday, March 30. Dr. W. H. Hadow, M.A., Hon. D.Mus., Principal, Armstrong College, Newcastle, on "English Music in the Tudor Period: Church Music" (Lecture I.). Saturday, April 1. Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres. R.S., Professor of Natural Philosophy, Royal Institution, on "Radiations from Atoms and Electrons" (Lecture IV.).

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, MARCH 24, 1916.

THE RAILWAYS IN WAR TIME.

THE reports of the railway companies for the past year disclosed but few details concerning the invaluable work they have accomplished for the nation during the year 1915, and this omission was little mended at the subsequent annual general meetings. For any adequate history of the working of our railways in war time we must await the end of the war. What is disclosed is that in spite of drastic reductions in the passenger schedules of the companies, the traffic handled has exceeded all records. This is true even if freight carried on Government account be excluded. The Government undoubtedly made an exceedingly good bargain with the companies on assuming control. Unkind critics, indeed, hint that it is the only good bargain they have made. Under the terms of the Act of 1871 it was provided that full compensation should be paid for the use of the lines, staff and plant, but the bargain actually struck was very much more favourable to the nation. Under it all military and naval traffic passes free of charge, and the Government merely bound themselves to pay over to the companies a sum equal to the net revenue received in 1913. Originally there was a provision reducing this amount in the proportion that the receipts for the first half of 1914 bore to those of the corresponding period of 1913; but on the companies agreeing to pay one-fourth of the first war bonus awarded to the employees, this provision was cancelled. The remainder of the first war bonus and all subsequent bonuses are being paid by the Treasury. Had the usual fares and freights been charged for the naval and military traffic, and the above agreement abandoned, the companies would undoubtedly have had an exceedingly prosperous year. The working of the lines is under the control of an executive committee consisting of the principal officers of the railway companies, and by the provision of these picked men, whose abilities have been tested in the stern field of competition, the debt of the nation to the companies is inestimably increased. No equally able staff could possibly have been provided by the less strenuous system adopted in our public departments, where high officials appear to have no difficulty in "doubling" the parts of Government servant and, say, dramatic critic. The well-founded charges of waste and incompetence in many departments of our national effort, where matters have been under the control of the ordinary Government official, provides a very instructive object-lesson when contrasted with the efficiency with which our railways have been operated.

As stated, the agreement with the companies was exceedingly advantageous to the nation, and, indeed, has proved to be inequitably so, as provision was not made for meeting certain perfectly legitimate charges. Thus under the stress of existing conditions it has been impossible to maintain the whole of the property of the companies up to the usual standard. Repairs and renewals have had to be postponed, and it is only fair that the costs thus ensuing shall be met by the nation, and this has been agreed to. Again, no allowance was made in the bargain on account of capital expended since the standard year of 1913. Much of this has now become productive, to the great advantage of the authorities; but although negotiations are in progress, the extra charges due on this capital have so far had to be met out of the amount paid over on the 1913 basis.

The agreement that no charges were to be made for military or naval transport has also not been without its disadvantages. Unless rumour lies, tons and tons of shells have been sent hundreds of miles to Woolwich for inspection, and then returned to the makers' works. Had freight been definitely charged on such consignments, arrangements would undoubtedly have been made for Mahomet, in the shape of the inspector, to go to the mountain rather than the task undertaken of transporting this mountain of shells to the inspector.

The agreement as it stands is renewable week by week, and some anxiety is felt as to the probable procedure of the Government on the conclusion of peace. If they merely terminate the agreement and cease forthwith to pay the war bonuses to the employees, the companies will be left in a very awkward position. Nationalisation has accordingly been suggested as a way out. This no doubt would suit the shareholders well, and provided no attempt was made to retrench at the expense of brains by reducing the managing staffs, the public would not suffer much at first. The disadvantages would only become serious as the responsible officers began to be replaced by the usual type of Government official, trained never to accept any responsibility that can by any possibility be evaded. Questions which are now settled offhand by the local representative of the company concerned would have to be referred to his superior, and again to the next higher officer in the scale of the official hierarchy. As Lord Sydenham has well said, the usual "chain of responsibility" in a Government department means that the man who knows all about a subject has to refer it to his superior, who knows less, till at last the matter is finally decided by someone who knows nothing whatever as to the merits of the question at issue. The House of Commons has, however, always preferred this plan to any other, as strong objection is taken to the risk of the occasional mistakes which must, in the nature of things, be expected when a reasonable amount of initiative is permitted to subordinates.

Possibly nationalisation would render a little easier the problem of wagon supply, but, as American experience shows, it is not a necessary condition. The main difficulties as matters stand are two—viz., the existence of private wagons, which could not be taken over without a special Act of Parliament, and, secondly, the natural reluctance of lines which are well equipped to share and share alike with less enterprising companies. A further difficulty is to be found in the fear, which possesses companies serving "producing" districts, that under a pooling system wagons would be kept waiting for a return load rather than returned

promptly to the place of origin. The out traffic from some districts is, in fact, necessarily greater than the in traffic, and an attempt to secure return loads in every case might occasion the greatest inconvenience. The difficulties of the problem of wagon interchange, no doubt, are great, but American experience has shown them to be by no means insuperable, and it is interesting to note that a wagon-pooling agreement has been entered into between the Great Northern, Great Central, and Great Eastern Railways. The Railway Executive Committee have suggested that the five Scotch companies should make a similar arrangement with each other, but the proposal has hardly been enthusiastically welcomed.

It should, moreover, be observed that the benefits to be achieved by pooling are often greatly overestimated. The practice has been, in returning wagons to the owning company, never to run them light if a load be available for any portion of the journey back.

The authorities have commandeered many of the steamers of the railway companies' fleets, and of these a proportion have been torpedoed or mined. From the London and North-Western Company the Hibernia, Anglia, Scotia, and Cambria were taken over. The Hibernia, renamed Tara, was torpedoed and sunk in the Eastern Mediterranean, and the Anglia struck a mine in the English Channel.

In spite of the war, considerable progress has been made in the further adoption of electric working. A particularly interesting example is the electrification of the mineral line between Shildon and Newport, County Durham, by the North-Eastern Railway Company. This is, we believe, the first instance of the kind in this country, but in America electric locomotives have been found far superior to steam locomotives for the hauling of heavy freight trains over difficult lines. The work of the Lancashire and Yorkshire Company in the Manchester district has been so lately described in our columns that further reference to it here is unnecessary.

Great delays have arisen in completing the electrification of the London and North-Western line to Watford and of the North London line. The normal working of the latter has, in fact, been much interrupted by Government traffic, and until matters mend, it will hardly be practicable to do more than work some of the existing services electrically, as any more frequent service, if established, would be constantly interrupted. It is hoped, however, that by September next it may be possible to adopt electric traction between Broad-street and Richmond. It is not yet possible to fix an approximate date for the opening of the service to Watford.

It had been hoped to commence the electrified services of the London and South-Western Railway early last year, but it was actually October before a start was made with the "roundabout" service through Richmond, Kingston, and Shepperton. The Hounslow service will be commenced this month, but there is now no expectation of completing the Hampton Court and Claygate electrification till next year. When this is done there will be a 5-minute electric service on the main line, with 10-minute services on the Hampton Court and "roundabout" lines. The London and South-Western Company have, perhaps, borne the brunt of the military-train services. From August 4, 1914, up to the end of January last they provided 15,000 special trains (exclusive of returned empties), in addition to further specials for soldiers on leave, and 2500 ambulance trains.

The London, Brighton, and South Coast Company's experience with electric traction continues to be very favourable, and extensions are slowly progressing. The passenger returns are 70 per cent. higher than in the last year of steam traction over the same lines, and the growth still continues, the returns for last year being 15 per cent. higher than in 1914. Last year the chairman stated that the company intended to continue their cross-Channel service from Dieppe to an unnamed port on the South Coast; but this port has, it appears, been required for other services, so that the company have merely been able to maintain an intermittent passenger service to Folkestone, making London the home port for their goods services. A very large number of trains have been run on Government account.

The South-Eastern and Chatham lines have also had a heavy military traffic, and have been inconvenienced by the serious landslip between Folkestone and Dover, and it is for the present impracticable to restore direct railway communication between these two ports. The South-Eastern appears to be the only company promoting a Bill this session. This inaction on the part of the other companies has been possible owing to the Act enabling extensions of time for authorised works to be granted by the Board of Trade without appeal to Parliament. The Bill promoted by the South-Eastern Railway is in substitution for an Act, already passed, authorising the construction of an additional bridge at Charing Cross. The new Bill has for its object the strengthening and improvement of the existing Charing Cross railway bridge. The proposal has, we note, excited the opposition of the architects in spite of the ludicrous fiasco which followed their violent criticism of the proposals of the City Corporation for a new bridge at St. Pauls. It will be remembered that on this occasion they succeeded in persuading some of the dailies and weeklies that the published plans were not bad merely, but so supremely inept that no one with the slightest pretence to artistic feeling could ever have promulgated them. In the sequel Parliament decreed that architectural opinion should be professionally consulted. Two architects of acknowledged eminence were retained accordingly, and these reported that the engineers had been perfectly right in their proposals. This report made the papers which had expressed so violent an opinion to the contrary look particularly foolish. It will be interesting to note whether this salutary experience will make the dupes of a few years ago somewhat more chary in accepting irresponsible architectural opinion at its face value.

It is further of interest to recall another bright architectural scheme for abolishing the present railway connection between the north and south of the Thames provided by the bridges at Blackfriars and the "widened" lines of the Metropolitan Railway. This cross-river connection has always been of great service for goods traffic, and during the existing crisis has been simply invaluable. Indeed, it has been necessary to suspend much of the passenger traffic over these widened lines in order to provide for the military traffic from the North of England to the south of the Thames. In fact, until architects exhibit greater breadth of view their advice on schemes of public utility should be accepted with caution. In theory, no doubt, they admit the importance of utilitarian considerations, as instanced by their maxim that the plan should determine the elevation of a structure, and not *vice versâ*; but in practice this ideal is commonly more honoured in the breach than in the observance, and we get in consequence the often inconvenient and bizarre garden city cottages, which, whatever the merits of their elevations and roof-lines, are the despair of the practical housewife.

A very large proportion of the railway employés have enlisted, and many others have attested under the "Derby" scheme. Including both these classes the percentage is in some cases as high as 87 per cent. of those of military age. Few railways have lost to the Colours less than 16 per cent. of their men, and since the traffic has been heavier than ever before in railway history, long hours and heavy work have necessarily been the portion of those left behind. It speaks well for the men that, in spite of this, complaints as to excessive hours have been actually less than in some recent normal years. This fact should be borne in mind when the purblindness of certain sections of workmen on the Tyne and Clyde raises fears as to whether democracy really deserves to win in this war between the aristocratic and democratic ideals. In excuse of the seemingly crass stupidity of those who continue to obstruct the output of necessary munitions, it must be borne in mind that in the early days of the war many of the more popular journals were prophesying a successful issue to the struggle in the course of a few months at most. Lord Kitchener's warning that the war would last three years was accordingly not taken to heart, and men were loath to abandon customs which, however indefensible ethically or economically, had behind them the tradition of many years.

The places of the absent railwaymen have been made good in part by harder work on the part of those left, and in part by the employment of women. The companies report very favourably on the results of this experiment, which may indeed lead to some important changes in methods of work. The Great Northern Railway, for example, are now analysing and making up accounts by unskilled girl labour which formerly required the services of a very expert and experienced clerical staff. This has become possible owing to the adoption of the Hollerith electric tabulating and sorting machines. These were, we believe, devised nearly a quarter of a century ago for analysing the United States census returns. The items to be analysed and aggregated are represented by holes punched in cards similar to those used for the Jacquard loom. These cards are fed into the sorting and analysing machines, which analyse and tabulate automatically the various entries.

It is a matter of common knowledge that five of the companies engaged in Metropolitan passenger transport have formed a combination. The companies in question are the District Railway, the City and South London line, the Central London Railway, the London Electric Railways, and the London General Omnibus Company. Of these five, only the District Railway is a controlled undertaking. The arrangement made between the companies is that each gives the other reasonable facilities for through traffic and without apportionment of fares. In place of this each company pays out of its receipts its preference charges and working expenses, handing over the surplus into a common fund. The aggregate thus formed is finally distributed amongst the five partners in certain agreed proportions. If any partner is, however, unable to meet its fixed charges, these become a first charge on the common fund. These lines have, on the whole, had a successful year, but the London General Omnibus Company has suffered considerably, partly from the large number of omnibuses requisitioned, and in part from the large loss of employees, whose services at the front have been invaluable. In fact, 30 per cent. enlisted, and a further 25 per cent. have since attested. The darkened streets have also had an adverse influence. The railways have done better, and the gross revenue of the District Company has for the first time exceeded one million. The return received by the shareholders is, however, still very low, even the second preference stock receiving only 3 per cent. In fact, as stated at the meeting, the cost of electrification was seriously underestimated, and the traffic during the early years overestimated.

The City and South London line now takes its current from Lot's-road. The extension of the Bakerloo Tube to Queen's Park is yielding good results, and interchange traffic has been increased by the escalators at Charing Cross. There is now a 15-minute service between Charing Cross and Willesden. All the London companies have been seriously hit by the increase of 71 per cent. on the cost of coal.

RADIATIONS FROM ATOMS AND ELECTRONS.

IN opening the second lecture of his course on the above subject at the Royal Institution on Saturday last, Sir J. J. Thomson, O.M., P.R.S., said that on the last occasion he had discussed the interpretation to be placed on the fact that Michelson had obtained interference between two rays of light, when the difference in the length of the paths traversed exceeded half a million wave-lengths. Such a result would be impossible unless there were a very great regularity in the wave-train. If the latter had been subject to changes either in amplitude or phase, interference would have been impossible. He had, moreover, raised the question whether it were possible for the mercury atom to persist in uniform vibration long enough to furnish a uniform train of 540,000 vibrations. Had the train passed through a long series of glass prisms, the necessary regularity in the train of waves would have been secured even had the source been intermittent, because the regularities observed in light dispersed through glass were a question of the length of the path, and not of the character of the source.

In the case of the mercury vapour examined by Michelson, however, the length of the wave-path through glass was quite insufficient to produce the results observed, which could not, in short, be accounted for by dispersion of the ordinary kind. Nevertheless, there were reasons for believing that, after all, the remarkable regularity of Michelson's wave-train was not to be attributed to a regularity in the radiating atoms of mercury, but to the influence of the medium by which they were surrounded. In fact, the mercury atoms, active at any instant, were surrounded by mercury vapour,

and if this vapour had a very intense dispersive power for mercury light, the effect in question might be due to its action, and not to the character of the actual vibrators. In fact, the principles on which dispersion depended gave reason for concluding that if a mercury arc were in the presence of a substance having an inordinate dispersive power, even a thin layer might be capable of producing the regularity observed.

The usual relationship between the refractive index and the frequency of light vibration was that the higher the frequency the more refrangible the light. Plotting the refractive index for glass against the frequency, yielded, in fact a quite common-place curve, having the general form indicated in Fig. 1. With some substances, however, an entirely different type of curve was obtained, and such bodies were said to show anomalous dispersion, and all of these bodies were

Fig. 1.

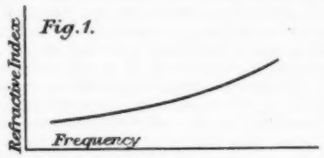
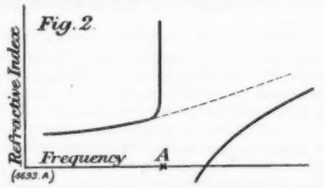


Fig. 2.

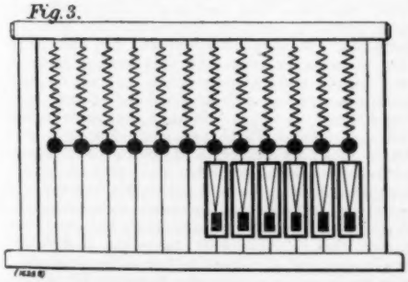


capable of giving out on their own account a definite kind of light. Suppose, in Fig. 2, that A represented the frequency of this light that they were capable of emitting. If the curve corresponding to Fig. 1 were drawn for a substance of this kind, it had the character indicated in Fig. 2. At the outset it resembled Fig. 1, but as the point A was approached the refractive index shot up as indicated, and theoretically became infinite at this point. Since the velocity of propagation was inversely proportional to the refractive index, this velocity became zero at A.

Proceeding to a little higher frequency, the square of the refractive index became negative, and none of this light could accordingly get through the medium. At still higher frequencies, however, light began to pass, and the curve continued as indicated in the figure. In the neighbourhood of A there was practically infinite dispersion, so that it was quite possible for a thin layer to produce the same effect on light of this wave-length as would a great length of path through glass.

To illustrate the character of the phenomena involved, the lecturer used a model represented diagrammatically in Fig. 3, with which he was able

Fig. 3.



to show the transmission of waves of different frequencies through a system having a natural frequency of its own. The model consisted of a series of balls hung from springs, and joined by a horizontal wire, as indicated. On the one side there were balls only, but on the other each ball was secured to a frame, in which was mounted a heavy pendulum, and all these pendulums had the same definite time of swing.

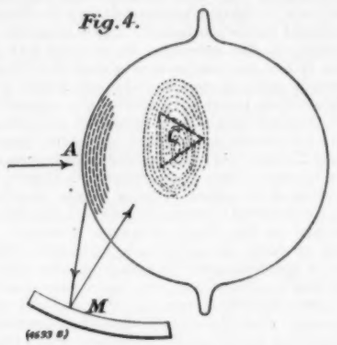
In a first experiment with this model, the ball on the extreme left was swung backwards and forwards at a much lower frequency than the natural frequency of the pendulums. The result was that a wave-motion was established along the horizontal wire connecting ball with ball. This wave, passing through the series of single isolated balls, was continued through those associated with the pendulums, and attention was drawn to the fact that the wave-length in this portion of the system was much less than it was in the section containing the isolated balls, which latter might, the lecturer said, be taken as representing the free ether. Since the wave-length was less in the pendulum portion, the velocity of propagation was also less there. On increasing the frequency of the disturbance, the wave-length in the pendulum section still further diminished and the velocity of propagation here became very small. In these experiments, the lecturer pointed out that the ball and the associated pendulum both moved together in the same direction. The frequency of the oscillation was next increased to a little beyond that corresponding to the natural time of swing of the pendulums. In this case, although the first unit of the series of balls with pendulums swung violently, the disturbance did not pass through the remainder of the series, but was reflected back along the series of isolated balls. This condition of total reflection, the lecturer pointed out, lasted over a considerable range of frequencies, but finally a point was reached at which the wave passed once more through the series of balls associated with pendulums. At this stage, however, the wave-length was longer in the pendulum portion than in the rest of the system, and in place of the balls and pendulum bobs swinging together they swung in opposite directions.

This model afforded, the lecturer said, an illustration of the passage of a wave through a refracting medium, having atoms with a definite period of vibration in their system. It indicated that with such systems a point was reached at which extraordinarily small differences in the frequency made enormous changes in the rate of propagation of the wave. Thus in the case of light in the neighbourhood of a point of anomalous dispersion, a 1 per cent. difference in the frequency might alter the velocity of propagation 10 to 12 times. At this stage we got, he said, resonance between the atoms and the incident light. He dared not, he continued, put the model shown into exact resonance, as it would all be shaken to pieces; but the effects of resonance could be shown with a simpler model. This model consisted of a spring, one end of which was fixed to the top of a vertical standard, and the other to a cross-head reciprocated by a crank. A weight was secured to the spring at mid-length. This weighted spring had, the lecturer stated, a natural frequency of its own, in which it would vibrate if disturbed. On setting the crank into slow rotation, he showed that the weight moved up and down in time with the cross-head, making "forced vibrations" of a frequency fixed by the rate of revolution of the crank. On setting the latter rotating at a high speed, forced vibrations were again produced; but although the frequency was still the same as that of the cross-head, the direction of motion was reversed, the weight moving up as the cross-head moved down. Finally, when the latter was reciprocated at a rate equal to the natural frequency of the weighted spring, resonance effects ensured, the weight jumping about in the most violent way possible. In this condition of resonance, the lecturer said, the weight absorbed energy from the crank, whilst in making its forced vibrations there was no absorption of energy.

This experiment illustrated, the speaker continued, how in the transmission of light there might be almost complete dispersion for one particular wave-length. An experiment by Professor R. W. Wood, of Baltimore, had a still closer bearing on an application of the theory which he wished to make. Professor Wood had shown that when light was passed through a vessel containing a trace of iodine vapour, but otherwise vacuous, a fog appeared in the path of the beam. This fog arose because the iodine vapour was violently excited by light of particular wave-length, and gave out light on its own account. That this was the case could be shown by putting different coloured screens in the path of the beam. In some cases the fog disappeared, whilst with others it remained practically unaffected. In a still more striking experiment, also due to Professor Wood, the iodine was replaced by sodium vapour.

In repeating this experiment, the lecturer focussed, on a bulb containing sodium vapour, the light from the salted flame of a Méker burner. He showed that in the region at which the light impinged there was intense reflection from the sodium vapour, and behind this reflecting layer there was a region distinguished by a faint glow. Professor Wood had, he said, modified this experiment, using the apparatus indicated diagrammatically in Fig. 4. The bulb shown was filled with sodium vapour at a pressure of less than $\frac{1}{1000}$ mm. of mercury. Light impinged on the bulb

Fig. 4.



from the left, as indicated, and was reflected at A from the vapour inside the bulb. This impinging light was, however, not quite homogeneous, but the reflected light was, and by means of the mirror M this reflected light was sent back into the bulb, where it produced the glow indicated at C. At this point in the bulb Professor Wood fixed a small triangle of magnesium oxide, as indicated by the dotted lines. This oxide reflected light as perfectly as white paper, but the reflecting power of the sodium vapour surrounding it was so great that its surface could not be seen, its two inclined edges alone being visible.

This experiment showed, Sir Joseph observed, that for light of the particular wave-length concerned, the reflecting power of sodium vapour under a pressure of less than $\frac{1}{1000}$ mm. of mercury was as great as that of white paper. In making this experiment, the speaker proceeded, it was necessary to get the wave-length exactly right, or there would be practically no reflection from the sodium vapour; but if the critical wave-length were correctly hit off, the reflecting power was altogether anomalous, and the little triangle disappeared in the fog thereby produced.

He would apply, he continued, these considerations to Michelson's experiment in which interference was obtained with wave-paths differing by 540,000 wave-lengths. Suppose, for example, that each mercury vibrator made only a few oscillations, thus giving rise to a certain disturbance. Any such disturbance could, by Fourier's theorem, be analysed into component harmonics or waves, each of which would spread out with its appropriate velocity. For the mercury atom the velocity of propagation for mercury light was practically zero, so that all the other Fourier components of the disturbance would move away, leaving that clear which corresponded to the vibrator of the mercury atom. It would thus be seen that the train of waves in Michelson's experiment might have been separated from the other components of the disturbance by the action of the mercury vapour around the luminous centres.

It was accordingly not possible from the data thus acquired to come to any conclusion as to the duration of the regular vibrations of the original luminous source. For this object it was necessary to go to work in a different way.

If a vibrating system did not vibrate for a long period, its effect could, the speaker went on, not be represented by a simple train of waves. The only disturbances which could not be resolved into a series of simpler component waves by Fourier's theorem was an indefinitely long train of simple waves, regular in amplitude and phase, and such a disturbance was the only known form of simple light. To a train 1000 wave-lengths long, of, say, sodium light, it would be necessary, in representing it by Fourier's series, to add other wave-lengths, to make up for the fact that the train had a beginning and an end, and these components would show in the spectrum, so that other lines would appear as well as the sodium light. The distance of these lines from the true line would depend on the length of

the original train. If the latter comprised 1000 vibrations, the satellites would be close to the original line; whilst with a train of ten wave-lengths only they would be far away from it. The thickness of a spectral line afforded accordingly one way of estimating the regularity of the original disturbance. Roughly speaking, the most important of the Fourier components (which had to be put in to represent the fact that the wave train had ends) had wave-lengths, which were equivalent to the loss or gain of one, two, or three vibrations during the time that the original excitation lasted. These gave the most important of the satellites to the original line. Hence, if the original train consisted of 1000 wave-lengths, a gain of one wave-length would give a satellite within 1 part in 100,000 of the original line. If the original train were still longer, the satellites would be nearer still. The satellites therefore widened the original line, and did so the more when widely separated than when close to it. Hence, from the widths of the spectral lines it was possible to find the number of vibrations made with undisturbed amplitude in the train of waves received. The results of such measurements indicated that in ordinary spectroscopic observations the train received and recorded as a line must have consisted of at least 100,000 waves, but this did not necessarily imply that the actual source had maintained its vibrations unaltered for a corresponding time.

A good idea of the fineness of the spectral lines was afforded by Lord Rayleigh's demonstration that the actual breadths as observed would be adequately explained by the Doppler effect, according to which a luminous centre approaching the observer would indicate to him a wave-length shorter than if it were receding from him. The ratio of the mean velocity of the luminous particles to the velocity of light was about the same as the ratio of the velocity of sound to that of light, and this motion of the atom was found to be of itself sufficient to explain the actual breadth of the spectral lines.

Sir J. J. Thomson referred back here to Wood's experiment in which monochromatic light was caused to pass through a bulb containing a trace of iodine vapour. If, he said, a regular train of waves fell on the iodine molecules, and if these molecules were subject themselves to any kind of interior disturbance, other lines besides that due to the incident light might be produced. This might have something to do with some remarkable phenomena described by Professor R. W. Wood, who had found in the spectrum of the iodine light produced in his bulb lines of a previously unknown character. Submitting the iodine vapour to light of a particular wave-length, Wood found that the spectrum showed one set of bright lines, whilst on using another kind of exciting light a quite different series of bright lines was observed. This effect might, the lecturer said, be produced by an irregularity in the motion of the iodine, although the light incident on it was itself quite regular. So long as the iodine particle was vibrating in unison with the incident light there was no disturbance and no energy was consumed; but if the iodine were disturbed in any way, then the incident energy would go into establishing free vibrations of the iodine system, and there would be absorption of the light. The effect observed could be explained if it were supposed that motion of the iodine particles was subject to interruptions—such, for example, as arose from the mutual collisions of the molecules, though these could not really be the determining cause in the phenomena under discussion. In such case the energy of the incident light would go into a shaking up of the iodine molecules.

The main point involved was that there was no absorption so long as the iodine was in phase with the incident light and that absorption would only arise when there were irregularities innate in the body through which the light passed. If such irregularities were present, we would get, in addition to the line due to the exciting light, a series of other lines having definite relations to the original line, giving satellites on each side of it, which would diminish in intensity the further their distance out from the parent line, and this distance out would be the greater the more rapid the frequency of the internal irregularities producing them.

Some action of this kind might, he thought, account for the observations made by Professor Wood. The cause could not, however, lie in the molecular collisions, as the results were independent of the pressure of the vapour. They must thus be due to something inside the iodine atom itself, in which there might be a periodic disturbance which superimposed itself on the exciting light.

To illustrate this point Sir J. J. Thomson made use of a heavy cross-bar suspended from a long helical spring. As is well known, when a helical spring is either compressed or extended, one end of it generally rotates a little with reference to the other. On pulling down the cross-bar and releasing it, the lecturer showed that the ensuing up-and-down oscillations gradually diminished, the energy passing into torsional oscillations, which a little later on were converted back again into vertical oscillations, and so on. The original up-and-down motion of the spring was, the speaker said, to be regarded as equivalent to the effects of the exciting light when no satellites were produced. The energy of this gradually passed into another form, and we had a periodic flow analogous to that between the energy of the torsional and vertical vibrations shown by the model.

If anything of this kind took place in the iodine atom, we should get superimposed on the regular line, due to the incident light, a series of satellites on each side. He would not go so far as to say that this was actually the explanation of the phenomena in question, but it did indicate that it might be quite possible to get a very complicated spectrum from the incidence of a particular line. He had, in fact, only introduced this matter to emphasise the principle that complicated spectra resulting from single lines were due to irregularities in the medium through which the light passed.

There was considerable evidence that the explanation of the absorption of light was to be looked for in some action of the kind described. In the text-books the matter was commonly dismissed by summarily asserting an analogy between the absorption of light and the phenomenon of resonance in the case of sound. Tuning-forks did, indeed, absorb energy from sound-waves of their own periodicity; but this fact explained nothing in connection with the absorption of light. All the time the tuning-forks were absorbing energy they were also giving out similar energy. To explain the absorption of light a conversion of the incident energy into some other form was necessary. The matter was not one of mere resonance, and opacity could be measured by the frequency with which the corresponding interruptions occurred. If they only occurred at long intervals of time, the body was transparent. The absorption of light was thus due to interruptions in the vibration of the atoms of the medium through which the light passed. In fact, it was only when there was considerable regularity in the train of the waves and in the vibrations of the atoms in the path of the light that the light escaped absorption.

THE NATURAL-GAS INDUSTRY.

ALTHOUGH natural hydrocarbon gases occur in large quantities in conjunction with coal deposits and igneous rocks, all known deposits of economic value are associated, either directly or indirectly, with petroleum or bituminous shales. From these latter sources the bulk of the gas produced is known as "dry" gas, and is obtained as the sole, or main, product from wells tapping large segregated gas deposits. It consists chiefly of methane with small quantities of ethane and other hydrocarbons. Gas is also obtained from oil-wells partly in solution and partly in intimate physical association with liquid petroleum; this gas is known as "wet" or "casing-head" gas. At the present time the natural-gas industry is confined almost entirely to the United States and Canada, the former country producing over 96 per cent. of the world's output in 1914. Some idea of the importance of the industry will be gathered from the fact that in 1914 nearly 592,000 million cubic feet of gas, weighing about 13,200,000 long tons, and valued at 19,336,000*l*., were produced in the United States alone, while the value of the gas produced in Canada was about 750,000*l*. These figures are taken from a very interesting paper on the subject recently read before the Institution of Petroleum Technologists, by Mr. J. A. Leo Henderson, Ph.D., F.G.S., M. Inst. M.M., to which paper we are also indebted for the following information.

Although it is recorded that natural gas was used for heating and lighting in New York State as early as 1821, the industry cannot really be said to have started until 1883, when an 8-in. high-pressure pipe-line, 35 miles long, was laid to convey gas to Bradford, Pa. Since that time a remarkable development has taken place, so that natural gas now takes sixth place in importance among the mineral products of the United States, if clay and cement are excluded. The gas was at first sold at almost nominal prices, and without being metered, a system that naturally led to an appalling waste of this valuable fuel; but the introduction of meters in 1891, and the subsequent steady increase in price, has done much to check waste by consumers. Even now vast quantities of gas are wasted in various ways. Leakage from pipe-lines alone, according to one authority, averages between 25 and 40 per cent. of the gas delivered into the pipes. This loss is largely due to the destruction of the rubber gaskets used for making the joints, though corrosion, blow-outs, and electrolytic action are all contributing factors. The enormous extent of this loss has only been realised in recent years, since the introduction of the orifice meter has provided a simple and efficient method of measuring large volumes of gas under the high pressure at which it is delivered into the pipes. Efforts are now being made to reduce the loss as much as possible by the employment of a new form of gasket, less affected by the constituents of the gas than rubber, though efforts in this direction are hampered by the low price obtained for the gas.

The average price in 1914 was 8d. per 1000 cub. ft., but prices ranging from ¼d. to 2½d. per 1000 cub. ft. are still common for gas supplied for industrial purposes, though the fact that it can be profitably employed at from 3d. to 1s. 3d. per 1000 cub. ft., in some cases, shows that a higher figure might reasonably be demanded. For domestic use the average price was 1s. 2d. per 1000 cub. ft., and as the calorific value of the gas is about 1100 B.Th.U. per cubic foot, this price is approximately equivalent to London manufactured gas at 7d. per 1000 cub. ft. Although natural gas is suitable for practically all kinds of industrial heating, it is pre-eminent for domestic heating, cooking and lighting, and, in Mr. Henderson's opinion, its use should be restricted to this purpose, to the generation of power in gas-engines, and to the smaller high-class industries. As a direct fuel in large industries, from 20,000 to 26,000 cub. ft. of gas are equivalent to 1 ton of good coal, so that in districts where the latter fuel is available at about 8s. a ton the gas would have to be sold, for this purpose, at less than 6d. per 1000 cub. ft., which is impossible if long-distance transmission is involved and the best principles of conservation are to be carried out.

The wet gas from oil-wells in the United States forms an important source of gasoline, 42,652,632 U.S. gallons of this commodity, valued at 182,872*l*., being obtained in this way in 1914. This quantity, it may be mentioned, is about one-third of the total consumption of motor-spirit in the United Kingdom in the same year. The gasoline is usually obtained by compressing and cooling the gas, though other methods of extraction are available, and the average yield is nearly 2½ U.S. gallons per 1000 cub. ft. The gas is also liquefied under high pressure, and used for general and household purposes. It may also be used for the propulsion of motor vehicles. In this form it is known as "gasol," and is distributed in steel cylinders having a capacity of about a cubic foot, and yielding 400 cub. ft. of gas. It has a high gross calorific value of 2400 B.Th.U. per cubic foot, and when burnt in a blow-pipe with oxygen the temperature obtained is said to be higher than that of the oxy-acetylene flame. Natural gas occurs in many other countries, notably in Hungary, Roumania, and Russia; and though not much has yet been done to exploit this valuable asset, there can be but little doubt that in the near future it is destined to play an imporant part in the economic life of these countries. In Australia also natural gas has been found in sufficient quantities to warrant a thorough geological investigation.

NOTES.

SULPHUR DIOXIDE SELF-DIFFUSER.

UNDER the title "Self-Diffuseur pour la Désinfection et la Dératisation des Tranchées," C. Galaine and C. Houlbert presented, on March 6, a communication to the Paris Académie des Sciences describing an automatic apparatus for diffusing sulphur dioxide. The liquid SO_2 boils at -8 deg. Cent., and has, at ordinary temperature, a high vapour pressure; but

the vapours are four times as heavy as air, and do not diffuse into air readily. Hence Galaine and Houlbert combine their apparatus with a heater and a ventilator; thus, complete in itself, the self-diffuser, consisting of three parts, is said to be fit for destroying not only ordinary insect pests and bacteria, but also the rats which infest the trenches. There is no mention of actual trials of the self-diffuser for the latter purpose, however. The sulphur dioxide is kept in steel cylinders of 3 mm. wall thickness; about 72 grammes of SO_2 are required under ordinary conditions to treat a cubic metre of air. The heater is a cylindrical vessel of sheet steel, charged with warm water; when used in the open it may be necessary to keep the water hot by means of a lamp. From the cylinder the SO_2 passes into a coil which lies in the heater. On the top of the heater is a drum containing a turbine wheel with eight aluminium blades, which is driven by the vapour pressure, and actuates a helical ventilator mounted above it. The ventilator is to suck up the air from the lower part of the room and discharge it above. When a trench is to be disinfected, the cylinder is placed outside the trench, the other parts being inside it; large cylinders of 100 kg. weight are suggested for getting rid of the rats. The apparatus can similarly be used for diffusing carbon disulphide, benzine and other vapours.

SEARCH FOR NEW COAL-FIELDS IN ENGLAND.

Discoursing on "The Search for New Coal-Fields in England," at the Royal Institution last Friday, Dr. Aubrey Strahan, F.R.S., Director of the Geological Survey of Great Britain, remarked that the saying of miners in the olden days, "No coal under red rock" (meaning red sandstone), had been disproved by geologists, and it was now understood that the search for coal might be successful anywhere, except where rocks older than the carboniferous formation came up to the surface. Yet coal was still being sought for in impossible places, as of old. Several of the great coal-fields probably extended further than was at present certain; in South Wales, *e.g.*, the coal-measures continued westward to Pembroke, and possibly under the sea; but their northward extension was improbable. The coal-fields of Durham and Lancashire also might have workable fringes further inland. But there was a belt of older formations between them, and another belt of formations older than coal-measures stretched from the district west of Dover *via* London north-westerly into the Midlands; there were, however, large tracts of unexplored ground on both sides of this diagonal belt, where no borings had been made yet. Reviewing the development of coal-measures with respect to three basins, Dr. Strahan first referred to the southern portion of the coal-field of Yorkshire and Nottinghamshire. Part of this field was "visible;" it soon became "concealed," however, and the superficial formations gave no clue as to dip. Bore-holes at Oxton and elsewhere had, however, seemed to indicate that the coal extended east right to the sea and possibly beyond, and this view had found favour especially on the Continent. But the Kelham bore-hole had not struck coal, nor millstone grit (which was overlying the carboniferous in the other parts), and the cup-shaped basin probably ended near the Trent Valley. The second example was that of the Denbighshire coal-field. There the dip was much steeper; but numerous faults had dislocated the strata to such an extent that a section suggested steps, and the coal-seams, while pitching up and down, remained for some distance near the surface, unfortunately, however, frequently covered by unproductive measures. The limit of workable depth was, after some fluctuation of expert opinion, now again estimated at 4000 ft.; great depth caused many difficulties, but the temperature trouble was the worst In Cheshire the coal seemed to be out of reach; a bore-hole at Northwich had at 2500 ft. only reached the new red sandstone. The third field considered, the Kent coal-field, west and north-west of Dover, was completely concealed, and the study of the geology of northern Europe had given the only clue as to its existence. By boring, coal had been found near Dover in 1856; yet in 1911 only 150 tons had been raised, and the total production up to 1915 was 350,000 tons, not particularly creditable to England. But there were exceptional difficulties, and the occurrence in recent formations of lignite had often deceived the searchers. In Kent the millstone grit was quite absent, and bore-hole sections through the strata had suggested to Dr. Strahan fairly regular contour lines of the carboniferous on both sides of an axis pointing from Dover to Freville and Canterbury. Much of the Dover coal-field was probably under the Channel, but the axis did not, as had been expected, form a continuation of the Artois axis. The direction of this axis was south-east in Northern France; at Douai it turned east, and then more north-easterly to Liége and into Germany. But the strata were stupendously distorted all along that axis, often literally turned upside down, whilst the strata along the Strahan axis were horizontal and regular, and it was much more likely that the Dover coal-field formed an extension of the Campine field which extended from the district north of Liége over to Antwerp. Kent had, in the commercial interest, been pricked with boreholes like a pin-cushion. Unfortunately this work, which might be of the greatest value, was not supervised by competent geologists; the geological department was not informed, and what they accidentally heard was generally unreliable, any hard rock being called a granite, and any black rock styled carboniferous. This British happy-go-lucky method still went on in spite of many protests and warnings, and the only report published on the Kent coal formation had appeared in a foreign journal (*Glück Auf*, of June 6, 1912).

THE SPRING MEETING OF THE INSTITUTION OF NAVAL ARCHITECTS.

The programme of the Spring Meeting of the Institution of Naval Architects, just issued, is gratifyingly extensive in view of the need for secrecy as to current work, experimental and practical, in connection with naval shipbuilding and marine engineering, and of the great pressure prevailing on all concerned with the production of *matériel* for the use of the sea and land forces of the King. The secretary, Mr. R. W. Dana, too, is to be congratulated on his arrangement of the programme, especially in view of the important work that he is doing at the Ministry of Munitions by permission of the Council. As was the case last year, there will be meetings on two days; but this year the members will meet not only in the forenoon and afternoon of the first day (April 12), but also in the evening, as well as at a morning and afternoon meeting on Thursday, April 13. Special interest attaches to the meetings owing to the fact that a new president falls to be elected, the five years of service of the Marquis of Bristol terminating now, according to the by-laws of the Institution. No doubt occasion will be taken to express to the noble Marquis the appreciation on the part of members of the professional ability, innate tact, and enthusiastic devotion which he has brought to bear upon the discharge of the work of the Presidency since he was elected. The President-Elect is the Earl of Durham, K.G., who has shown on many occasions keen interest in all that affects the Royal and mercantile fleets of the United Kingdom, and was specially prominent at the combined meetings of Naval Architects on the North-East Coast two years ago. The first paper to be read at the meeting on April 12 will be by Sir Philip Watts, K.C.B., who will deal with the work of the Load-Line Committee, of which he was chairman, and the report of which we reviewed at considerable length in last week's issue. Mr. W. S. Abell, Chief Ship Surveyor, of Lloyd's Register, will also deal with some questions in connection with the same report. At the afternoon meeting, three papers regarding the resistance of ships are to be read: the first by Dr. Chas. H. Lees, on "The Laws of Skin Friction of a Fluid in Stream-Line and in Turbulent Motion along a Solid of Great Length," and the second by Mr. G. S. Baker, of the Froude Tank, on "Skin Friction Resistance of Ships and our Useful Knowledge of the Subject." In view of the good work done at the Tank, not only in independent research, but at the request of merchant shipbuilding firms, the discussion of this subject ought to be of special interest. Of a kindred nature is the paper by Professor T. B. Abell, of Liverpool, on "Experiments to Determine the Resistance of Bilge-Keels to Rolling." Colonel G. Russo, of the Russian Imperial Navy, will deal with the interesting subject of "An Experimental Tank Reproducing Wave Motion," regarding which he has given much attention for a number of years. At the evening meeting on April 13 there is promise of a discussion on the important subject of the present position and possibilities of the marine Diesel engine, regarding which a paper is to be read by Engineer-Lieutenant W. P. Sillince. Mr. J. Denholm Young is to read a paper on "The Co-Ordination of Propeller Results," and Mr. T. C. Tobin on "The Maximum Propulsive Efficiency of Screw-Propellers." The Thursday forenoon meeting will be devoted entirely to reports of the Bulkhead Committee, whose deliberations extended from 1912 to 1915, and regarding whose work we wrote at considerable length in our issues of January 8 and October 15, 1915. The President of the Committee, Sir Archibald Denny, Bart., will read the first paper, which is on the "Sub-Division of Merchant Vessels." Mr. J. Foster King, who conducted extensive experiments on behalf of the Committee (of which he was a member), will deal with "The Strength of Water-Tight Bulkheads," and there will also be read a paper on the effects in practice of the Committee's recommendations. On the afternoon of Thursday, the first paper, by Mr. John Reid, will deal with a collision case, and Mr. M. G. de Gelder will contribute a paper on "The Shipyard Cranes of the Rotterdam Dockyard Company." As the last word has certainly not been said regarding the crane equipment of shipbuilding berths, his contribution ought to give rise to a useful discussion. It will thus be seen that the Institution, notwithstanding the difficult times in which we live, particularly for naval constructors, will maintain the high repute which has been gained at the meetings in past years.

SCIENTIFIC AND INDUSTRIAL RESEARCH.

It will be remembered that some eight months ago it was announced by the Government that a scheme had been designed for the promotion of scientific and industrial research, this scheme providing for the establishment of a Committee of the Privy Council which would be responsible for the expenditure of any new moneys provided by Parliament for the researches contemplated, and of a small Advisory Council which should be responsible to the Committee of Council and which should be composed mainly of eminent scientific men and men "actually engaged in industries dependent upon scientific research." It was further stated that it was contemplated that the Advisory Council would work largely through sub-committees appointed to deal with various branches of industry.

The whole scheme is undoubtedly one of far-reaching importance, and we hope in due course, when the details of its organisation are further matured, to deal with it fully. Meanwhile, in view of the fact that the complete development of the scheme is naturally very materially delayed by the existing condition of public affairs, it will be of interest to put on record the initial action which has been taken by the Advisory Council. In order to secure that researches already in progress should be continued in spite of the war, the Advisory Council issued to various scientific and professional societies invitations to apply for aid to continue researches which they had already undertaken, and for which the necessary staff and equipment were obtainable. As a result, grants have been made to the Institution of Mechanical Engineers in aid of researches on "Hardness Tests," and on "The Properties and Composition of Alloys;" to the Institution of Electrical Engineers, for researches on "The Heating of Buried Cables," and on "The Properties of Insulating Oils;" to the Institute of Chemical Industry, for investigations relating to "Laboratory Glass" and "Optical Glass;" to the Institution of Mining and Metallurgy, for researches on "Methods of Extracting Tin and Tungsten;" to the Institute of Metals, for researches on "The Corrosion of Non-Ferrous Metals;" to the Institution of Gas Engineers, for investigations relating to "Refractory Materials;" to the Manchester Association of Engineers, for "Experiments on Tool-Steel;" and to the National Physical Laboratory, for researches on "Optical Glass."

The Advisory Council has also recommended a grant in aid of a research bearing upon the manufacture of hard porcelain, this being an important new investigation which has been undertaken by the governing body of the Stoke-on-Trent Central School of Science and Technology in conjunction with the Staffordshire Potteries Manufacturers' Association, the object being to establish the manufacture of hard porcelain in this country.

As regards the Committees which it is intended should be appointed by the Advisory Council, we understand that strong Committees on Mining and on Metallurgy have been already constituted. The Mining Committee has two sections: one dealing with the mining of non-metals, and having as chairman Sir William Garforth; while the other, with

Mr. Edgar Taylor as chairman, will deal with the mining of metals. The Metallurgy Committee will also consist of two sections, dealing respectively with ferrous and non-ferrous metals, Sir Robert Hadfield, F.R.S., being the chairman of the former, and Sir Gerard Muntz of the latter.

It will be seen from the above brief statement that the Advisory Council have made an excellent start on actual work, and it is especially satisfactory to note that the researches to which they have so far given their support are in the hands of important scientific societies whose Councils have already had experience in research work, and who will be able to exercise that constant supervision and control which is so essential to ensure that work of this kind shall really afford practical benefit to the particular industries in whose aid it has been undertaken.

THE FAN DYNAMOMETER: ERRATUM.—Mr. J. L. Hodgson informs us that there was a misprint in the formula given in his paper on the above subject, and reproduced in our last issue. The value of W, given near the bottom of the second column, page 262, should accordingly read:—

$$W = \frac{1.317 \times \text{barometric pressure in inches of mercury}}{(460 + \text{temp. Fahr.})}$$

We have to thank Mr. Hodgson for this correction. He states in his covering letter that the above value of W is correct to within $\pm$ 0.25 per cent. for air under ordinary atmospheric conditions (as regards moisture and CO_2 content), between 40 deg. and 80 deg. Fahr.

DIRECTORY OF BRITISH MANUFACTURERS FOR THE RUSSIAN TRADE.—This interesting directory is issued by the Russo-British Trade Exchange, Limited, 16, Regent-street, London, the general manager of which is Mr. R. A. Lenski; it is printed in the Russian language, for circulation in Russia, with the object of diverting to British firms the very large Russian trade formerly captured by Germany. The directory contains about 400 pages, with trade headings in Russian and English; it gives also a brief supplement in English, entitled "Sidelights on Russia," and a large number of advertisements. It bears evidence of very careful compilation, and has evidently received the support of representative British manufacturing firms. It is published at 5s. by the Russo-British Trade Exchange, Limited, which company also undertakes to supply reports on the standing of Russian firms, the placing of advertisements in Russian publications for British manufacturers and shippers, and is in a position to give expert advice with regard to Russo-British trade.

WIRING RULES (SEVENTH EDITION), 1916.—In order that the Wiring Rules may be kept in conformity with the developments in electrical practice, they have been revised by a committee, the constitution of which is set out on the back of the title-page of the pamphlet containing them, issued by the Institution of Electrical Engineers. Among the changes in this edition may be mentioned the extension of the rules to include medium pressures, the provisions made for conductors with hard rubber-compound protection, the addition of a table showing the capacity of conduits and the rule recommending colours for the conductors. The table has now been printed in the rules instead of on a separate sheet. The new rules have been adopted by the principal fire offices, and they are accepted as standard practice, and their use is recommended by most supply authorities. The price of the rules is 6d. per copy (or 7d. post free), and copies can be obtained from the Secretary of the Institution of Electrical Engineers, or from Messrs. E. and F. N. Spon, 57, Haymarket, S.W.

TRADE AFTER THE WAR.—The President of the Board of Trade has decided to appoint committees to consider the position of certain important British industries after the war, especially in relation to international competition, and to report what measures, if any, are necessary or desirable in order to safeguard that position. The Committee for the Shipping and Shipbuilding Industries is constituted as follows:—Sir Alfred Booth, Bart., chairman of the Cunard Steamship Company; Mr. W. S. Abell, Chief Ship-Surveyor to Lloyd's Register; Sir Archibald Denny, Bart., a partner in the firm of Wm. Denny and Brothers, shipbuilders, of Dumbarton, and chairman of the Committee on Bulkheads; Sir E. Hain, a London and Cardiff shipowner and a member of the Transport Advisory Committee; Captain H. B. Hooper, joint managing director of the General Steam Navigation Company; Mr. James Readhead, managing director of John Readhead and Sons, Limited, shipbuilders, of South Shields; and Mr. Oswald Sanderson, managing director of the Wilson Line. Sir Alfred Booth is chairman of the Committee. For the Iron, Steel, and Engineering Industries the following form the Committee:—Sir Clarendon Hyde (chairman), a partner with Lord Cowdray in the firm of Messrs. S. Pearson and Son, Limited, contractors for public works; Mr. Arthur Balfour and Mr. A. J. Hobson, prominent Sheffield engineers and manufacturers; Sir Hugh Bell, Bart., the well-known Yorkshire iron-master; Sir Hallewell Rogers, chairman of the Birmingham Small Arms Company; and Mr. Douglas Vickers, a managing director of Vickers, Limited. All communications relating to the Committee should be addressed to Mr. Percy Ashley, the Board of Trade, S.W. The Constitution of a Committee for the Textile Industries will be announced shortly.

INDUSTRIAL NOTES.

THE Minister of Munitions announces that he has made further Orders under Section 4 of the Munitions of War Act, 1915, under which twenty-six additional establishments have been declared controlled establishments under the Act. A total of 3078 establishments has now been declared as controlled under the Act from the date of the first Order, July 12, 1915, up to March 17, 1916.

The Director of the Department of Labour Statistics states, in the *Board of Trade Labour Gazette*, that retail prices of food on March 1 in the United Kingdom were higher than on February 1 by about 1 per cent. Mutton showed an advance of over 3 per cent. on the average, but beef showed a comparatively small increase. Flour and bread prices rose about 2½ per cent., as compared with 6 per cent. last month. There was an increase of 7½ per cent. in the price of granulated sugar, of 4 per cent. in the price of margarine, and of 3 per cent. in that of cheese. Butter increased slightly on the average, as also did potatoes, while milk, tea, and bacon remained practically unchanged in price. Eggs and fish were the only articles for which a decline was recorded, the average percentage changes for these being 12 and 4 respectively.

As compared with March 1, 1915, the general level of prices showed an increase of about 19 per cent.

Taking the country as a whole, and making allowance for the relative importance of the various articles in working-class household expenditure, the average increase in the retail prices of food since the beginning of the war may be put at 48 per cent. This figure relates to food only, and in estimating the increased cost of living this percentage must not be applied to the total family expenditure, but only to that proportion which is expended on food.

During January a rise of 2.8 per cent. was recorded in retail food prices in Berlin, and the general level of certain of the more important articles of food was 88.5 per cent. above that of July, 1914. In arriving at these results allowance is made for the relative importance of the various articles in working-class consumption. The *Board of Trade Journal* quotes figures published in the Prussian official journal *Statistische Korrespondenz*, and adds that the percentages given in the said German publication can no longer be said to indicate the full extent to which the normal food supplies of Berlin have been reduced in quantity owing to the war. Some of the prices recorded are maximum prices beyond which retail dealers are not allowed to charge. Some articles, again, such as bread, flour, butter, pork, milk and lard are purchasable only in strictly limited quantities, while others, such as beans, peas and lentils, would appear to be practically unobtainable at the ordinary shops.

The Badge Department of the Ministry of Munitions has been transferred from 29, Abingdon-street, S.W., to 4, Whitehall Gardens, S.W. Personal inquiries should be made at the latter address, but correspondence should be sent to the General Secretary, Ministry of Munitions, 6, Whitehall Gardens, S.W., and marked "Badge Department."

A difference having arisen between the King's Norton Metal Company, Limited, of the Ammunition Works, Abbey Wood, and the Amalgamated Society of Engineers as to the rate of payment to men on night-shift, and the matter having been reported to the Board of Trade, it was referred by the Board of Trade to arbitration, in accordance with the provisions of the Munitions of War Acts. The parties having agreed to the difference being determined by a single arbitrator, the Board of Trade appointed Mr. William Warrender Mackenzie, one of His Majesty's Counsel.

By an agreement between the Amalgamated Society of Engineers and the Employers' Association, dated November 11, 1911, it was provided that "time and a quarter" should be paid to men employed on night-shift by firms in the Erith, Belvedere, Dartford, and Crayford district.

The contention of the King's Norton Company was that in paying time and a quarter for night-shift at their works they had followed the custom obtaining in the case of neighbouring firms in the Erith, Belvedere, Dartford, and Crayford district, members of the Employers' Association, and the practice adopted by the company during the South African War (1899-1902), when they worked night-shifts at their works.

The precise boundaries of the area included within the term "Erith, Belvedere, Dartford, and Crayford district" in the agreement between the A.S.E. and the Employers' Association were not defined. The agreement appeared to have had in contemplation the industrial district lying south-east of, and adjacent to, the district of Woolwich (including Woolwich Arsenal), and in the opinion of the arbitrator it was in this industrial district that the works of the company might properly be said to be included, and not in the London district.

Having regard to this finding of the arbitrator, it was unnecessary for him (he added) to decide upon the claim, which was made by the Amalgamated Society of Engineers and disputed by the King's Norton Company, to the effect that "time and a half" should be regarded as the established rate of payment for night shift in the London district, and accordingly he made no finding on that matter.

Having considered the evidence and statements laid before him by the Amalgamated Society of Engineers and the King's Norton Company and all the circumstances of the case, the arbitrator decided that the claim of the Society that the King's Norton Metal Company should alter their practice of paying "time and a quarter" and pay "time and a half" for night shift had not been established.

An adjourned case against Thomas Rees, London district secretary of the Amalgamated Society of Engineers, was heard last Saturday at Bow-street Police Court. The case was withdrawn by the Ministry of Munitions, with the permission of the Chief Magistrate, upon the following undertaking being given in Court on behalf of the London district committee of the said Society:—1. The district committee admit that they authorised and countenanced what Rees did. 2. They rescind all resolutions ordering the men to strike, sanctioning the strike and Rees's action in connection with it. 3. They cancel all fines imposed in connection with the strike on any of the men working at the King's Norton Company's works. 4. They undertake that the men at the King's Norton Company's works shall in no way be prejudiced as members of the Amalgamated Society of Engineers by reason of their connection with, and action in, reference to the strike.

In the monthly report of the Amalgamated Society of Engineers it is stated that with the opening out of national factories there was a demand for more skilled men, and there was continual pressure by the Government officials for the drastic dilution of labour. The demand was such that only eighty engineers out of a membership of 208,825 received out-of-work benefit in the United Kingdom. In the Leeds and Halifax districts the demand for men and the dilution of labour was very keen on the part of employers, but omissions to pay the rates of pay laid down in connection with the scheme had caused some trouble. Trade in the Sheffield division was reported to be very good, and all the society's members were fully employed. The dilution scheme was now stated to be operative in several places on the North-East Coast.

Owing to the great shortage of labour in the cotton trade, the British Association of Managers of Textile Works (Lancashire Section) has decided to send to each of its members the following notice to women:—

"In the national interest production should be maintained at its highest level, and you are doing your bit for the war by not leaving your employment in the mill for employment of an unproductive character. Such occupations as tram-conductors, postmen, and similar work can be filled by persons who have not had experience in textile mills.

"The imports to this country, such as foodstuffs, raw material, and munitions, are not paid for in cash, but are paid for by the exports of manufactured goods from this country. Cotton cloth is one of our chief exports, and if we are to meet the war expenditure, which amounts to 5,000,000*l.* sterling per day, it is a vital necessity to maintain at its highest figure the nation's exports. Every loom stopped means a loss to our home or export trade, and therefore a loss to the country."

In conjunction with the above it is interesting to note that a meeting convened by the Women's War Interests' Committee was held on Saturday last at Manchester. Councillor Margaret Ashton occupied the chair. The committee in question was formed last May to meet the crisis arising from the withdrawal of a large number of men from industry and their substitution by women. In order to combat the danger of the fall of the standard rate of wages, the lowering of the standard of life of the workers, and the injury to health of the women workers themselves, the committee formulated the following demands:—

1. A minimum wage of 1*l.* a week of 48 hours for adult women engaged on war work, with piece rates as for men.

2. A three-shift system, or restriction of night work for women to three weeks out of six.

3. The provision of proper canteens for night-workers.

Most of the time at Saturday's meeting was taken up by the consideration of a resolution to the effect that "No woman shall work now or be retained after the war in engineering shops at less than the recognised trade-union rate of wages when employed on work hitherto done by men. Where a recognised

trade-union rate does not exist, the wages should be not less than 1*l.* for a week of 48 hours."

The resolution was passed after substituting the words "in any trade" for "engineering shops."

During the discussion on the resolution a speaker stated that the engineers had not agreed that women's labour should be retained after the war. The agreement with the Government was that the women should only work during the war. In answer to a question, the speaker added that after the war the engineers were going to "weed out" the women. This view was opposed by several delegates, who said that women would have to work after the war in the occupations they were now in.

Another speaker said he wanted the engineers to recognise that the women were in the shops for ever. The engineers' delegates were trying to create a sex war. Were they going to turn the women into the streets after the war? They could no more stop the increase of women in industry than they could stop the evolution of the machine in industry.

An amendment to leave out the reference to conditions after the war was defeated by 63 to 53 votes, and the resolution was passed, as above stated.

Another resolution, which was carried with two dissentients, read:—"That a woman displaced by the cessation of the war should receive, in addition to any benefit she is entitled to under Part II. of the Insurance Act or from her trade-union, adequate out-of-work benefit, either till she gets work or for a period to be agreed upon, and that the unemployment benefit should be a charge upon the Government."

It is announced that the Liverpool shipping companies who had been employing women dock labourers have decided to discontinue the experiment, and have paid off all the women, in order to avoid further trouble with their ordinary dock labourers. We referred to this question on page 264 *ante*. In dealing with the matter, the *Liverpool Courier* says: ". . . This is not the fault of the women. Nor is it the result of anything done by the employers. The responsibility for women being rejected from the field of labour at the docks lies with the dockers. . . . Some of the dockers, it should be stated, were not opposed to women workers. They were rather impressed with the novelty of the idea, and admired the spirit of the women, and so they were disinclined to raise any objection. But the union took a firm attitude on the matter, and it was very largely as a result of this attitude that the men absented themselves from work where women were being employed. . . ."

A meeting of the Clyde District Committee of the Federation of Engineering and Shipbuilding Trades was held at Glasgow last Tuesday. At the close of the meeting it was stated that the question of the Committee on Production's recent finding in the application for an advance of 2d. per hour in wages had been very carefully and seriously considered. A line of action was decided upon unanimously, and a sub-committee was appointed to submit the terms of a resolution to the Local Advisory Board, the National Advisory Committee on War Output, the Executive Committee of the Federation, and the Government. It was arranged to hold a public demonstration of the workers affected within the next fortnight.

Sir George Askwith, the Chief Industrial Commissioner, conferred last week with representatives of the South Wales coal-owners and of the miners on the question of employment of non-unionists in the pits. An agreement was reached between the parties, which provides that during the war the men employed at the collieries shall be required to become members of the South Wales Miners' Federation, and, in order to avoid disputes, the employers agree to co-operate with the workmen to secure this result. The coal-owners agree to supply each fortnight to the local agent of the Miners' Federation a list of the workmen employed at the colliery, giving the names of the workmen engaged during that period. In the event of any dispute occurring the workmen agree not to give notices to cease work, but to refer the case to the Chief Industrial Commissioner for his decision. On their part the Miners' Federation undertake to suspend the use of "show cards" by the workmen employed where notices have been given to cease work.

Efforts are being made to bring the new arrangements into operation at the earliest possible moment.

Apart from this there is, unfortunately, a dispute with regard to hours and payment for the Sunday night-shift, the payment of a bonus turn to "outlers," and increased wages to surface craftsmen. A meeting is to be held on Monday next at Cardiff, when it is proposed to tender a two weeks' notice to secure the settlement in regard to these points.

QUEENSLAND MINERALS AND THE WAR.—The Government is completing now a State battery for the treatment of molybdenite in the Herberton and Chillagoe districts.

"ON THE WHIRLING SPEEDS OF LOADED SHAFTS."

TO THE EDITOR OF ENGINEERING.

SIR,—In his reply to my letter, published in your issue of March 17, Mr. Kerr is hardly just in suggesting that I adopted the arithmetic mean of the various diameters as my equivalent diameter. I fixed upon 0.28 in. quite arbitrarily, after having considered the stiffening effect of the wheel and the enlarged portion of shaft. I intended it as an extreme case, and in my first letter stated clearly that the correct critical speed would lie between the values found by using the diameters 0.28 in. and 0.25 in. respectively. I, of course, assumed that the enlarged section extended the full length of the wheel-boss, and am surprised to learn that it only extends half that distance. Mr. Kerr states this is usual practice in small rotors, but I must confess it is the first instance of such a construction I have ever heard of.

However, he confirms that by my method a result not far removed from the experimental values is obtained.

The question of the exact equivalent diameter is, however, of secondary importance in most cases, and I do not propose to labour this point further.

I cannot, however, concede Mr. Kerr's contention that bearing No. II. can be neglected. It is bound to constrain the vibrations of the shaft unless abnormally slack.

With regard to bearing No. I., Mr. Kerr states that Professor Dunkerley used "fixing" bearings 10 to 12 diameters long, and that the bearing in question should be regarded as fixed because it is 9 diameters long.

This does not follow, however. The Professor would probably see to it that his bearings were rigidly mounted, and if Mr. Kerr cares to examine the construction of the housing supporting bearing No. I., I am certain that he will modify his views as to its absolute rigidity. The Professor's bearings were probably plain brass, and a good fit on the shaft, as they were not called upon to stand up to constant running.

On the other hand, rotor bearings are designed for constant service, and are lined with white metal. This metal is expressly used because of its ability to yield at points where it is heavily loaded, so that the rest of the surface may do its duty. And, lastly, the running clearance in such bearings is quite a measurable amount, as Mr. Kerr can easily ascertain with the aid of a piece of soft lead wire.

Taking all these conditions into account, I still see no reason to regard journal No. I. as other than simply supported, but agree with Mr. Kerr when he says "the centre of support is, admittedly, not quite so far out as the centre of the bearing." How far is the problem to be settled, and I put forward the theory of the inner edge to invite criticism on the subject.

I would ask Mr. Kerr to regard my suggestion of a lower value of the critical speed when slowing down not as the result of an idea, but of personal observation.

In conclusion, I wish to thank Mr. Kerr for his very able article on a very difficult subject, and also for his courteous reply to my previous letter.

I remain, Sir, yours faithfully,

Glasgow, March 20, 1916. G. H. HENDERSON.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Kerr's article raises a question on which wider experimental information is very desirable.

It is well known that the critical frequency n of transverse vibration of a shaft rotating with an angular velocity ω is

$$n = \frac{1}{2\pi}\sqrt{p^2 - \omega^2}$$

which become $p/2\pi$ when $\omega = 0$.

If a rythmically repeated disturbance equal in frequency to that of rotation of the shaft, and coinciding also with that of the critical frequency of the rotating shaft, arises,

$$n = \omega/2\pi$$

and

$$\omega^2 = \tfrac{1}{2}p^2,$$

or

$$\omega = \frac{1}{\sqrt{2}}p.$$

This is a critical speed of rotation which is about 71 per cent. of the whirling speed p. The effect of the resonant vibration, if continued, would be almost that of whirling. But this critical speed does not, like the true whirling speed, involve complete instability, and it may be supposed that serious disturbance would take much more time to develop under such a disturbance as that of gravitation on a horizontal shaft than in whirling due to instability.

It would be interesting to know, in the case of other machines, the critical speeds of which have been carefully estimated, whether or not disturbance has been actually found to occur at about 70 per cent. of the calculated whirling speed.

Yours faithfully,

ARTHUR MORLEY.

6, Rectory Drive, Gosforth, Newcastle-on-Tyne,
March 20, 1916.

"RADIATIONS FROM ATOMS AND ELECTRONS."

TO THE EDITOR OF ENGINEERING.

SIR,—In your interesting *exposé* in the current issue of ENGINEERING of Sir J. J. Thomson's introductory lecture the following pregnant paragraph appears:—

"It was accordingly impossible to tell from the reflections produced by a grating anything as to the nature of the source, since the grating would produce light of definite wave-lengths, even when there was nothing of the kind in the original light."

1. Are we to understand that, for instance, solar eruptions which produce deflection effects, and have hitherto been attributed to movement in the line of sight of solar material, cannot with surety be taken as *bond-fide* ocular demonstrations of the Doppler-Fitzeau principle?

2. Are we to take it, in cases where the time a solar commotion endures is coupled with the amount of deflection observed and the altitude of a prominence thereby calculated, that this is misleading, inasmuch as it is now suggested that there is fictitious prolongation of the optical phenomenon we observe to be taken into account, which, if analysed in the light of Sir J. J. Thomson's theories, would tend to indicate that the velocities on which the calculation is based are *under* estimated rather by taking the time factor too long?

3. Are we further to take it that all the laborious lists of stars based on their spectra, constitution, age, translation in space and direction, are rendered dubious, because the reading of the above-cited paragraph admits hardly of any other interpretation?

4. It can be read in many text-books that the velocity of light through the ether is the same for red rays as for violet rays, although none of these same text-books adduces the slightest actual proof in support of the assertion. I, for one, have always doubted the assertion *per se*, nursing a strong conviction that violet rays travel through ether and space faster than red rays, although the difference may be small and difficult to detect.

Yours respectfully,

ALBERT ALFRED BUSS.

29, Peter-street, Manchester, March 20, 1916.

THE PAPUAN OIL-FIELDS.—Important developments are understood to be imminent in regard to the work of prospecting for oil in Papua. Up to the present, all prospecting has been carried out by the Government, but strong representations have lately been made to the Australian Minister for External Affairs (Mr. Mahon) in favour of permission being given to private prospectors to carry out experimental boring on the field.

AUSTRALIA AND RUSSIA.—M. Wassili de Devison, the Russian Trade Commissioner, recently had an interview with the Australian Minister of Customs (Mr. Tudor) on the subject of improving the trade relations of Australia and Russia. Mr. Tudor stated subsequently that the Russian Ambassador discussed the question whether it would be possible to extend the "favoured nation treatment" to his country. He pointed out that Russia used a large quantity of Australian goods, particularly wool and tallow, but they had previously got these mostly through Germany. They were anxious to establish direct trade with the Commonwealth. He (Mr. Tudor) assured his visitor that his sympathy was with the Ally of the British Empire in the matter. He would do everything he could in the direction of establishing direct trade. Regarding the preferential treatment of Russia, that was a matter for Parliament to decide when considering the tariff.

ODESSA.—The exports of iron ore from Odessa in 1914 were 238,225 tons, of which 31,700 tons went to the United Kingdom, and the balance of 206,525 tons to Rotterdam, in transit for Germany. The Odessa iron-ore export trade, which was at one time carried on mainly with the United Kingdom, fell into German hands. The cause of the trade leaving Great Britain was that the sorting of ores in Russian mines did not suit the British markets, on which ores of high quality only, containing over 62 per cent. of iron and with no phosphorus, are in demand, while 50 per cent. of the shipments should be in lumps. The Germans, on the other hand, were willing to buy ores containing as little as 55 per cent. of iron and as much as 0.02 per cent. of phosphorus. They are willing, also, to allow 35 to 45 per cent. in lumps. As a consequence of all this, the entire trade fell into their hands, and they shipped superior qualities of Russian ores to the United Kingdom at a good profit. For the first six months of 1914 the output of the Krivoi Rog mines was 3,030,000 tons, of which about 70 per cent. were despatched abroad; manganese ores were shipped in 1914 to the extent of 27,157 tons—all for Antwerp.

ZINC IN GERMANY.—The German zinc industry is said to have been successful in 1915. The demand has been exceedingly active, partly for military purposes and partly as a compensation for other metals, of which the war has curtailed the supply. This favourable development has brought about an almost continuous rise in the quotations, which have been as high as 69 marks per 100 kg. (220 lb.), and now stand at 66 marks, whereas the average price for 1914 was 47 marks, and for 1913, 46.50 marks. The rise of about 20 marks during 1915, which is materially below the corresponding rise in England and America, has certainly, to no small extent, been neutralised by higher cost of production; but very satisfactory results have accrued to the works. The two largest West German zinc works—the Rhenish-Nassau concern and the Stollberg Zinc Works—have done well. The Rhenish-Nassau Company will declare a dividend of 16¼ per cent. for 1915, against 6 per cent. for the previous year, with writings off amounting to about 1,200,000 marks, against 752,765 marks for 1914, and less than 600,000 marks for a number of preceding years, when the dividend sometimes rose to 24 per cent. The Stollberg Mining Lead and Zinc Company pays 9 per cent., against 4 per cent. for the preceding year, with 1,338,769 marks written off, which is rather more than usual, and 2,833,195 marks added to reserve, against 396,067 marks the preceding year.

THE MURCHEY COLLAPSING MACHINE TAPS.

THE accompanying illustrations show a collapsing tap which is now being largely employed for tapping the holes in the noses of shells, and for other work in connection with the manufacture of munitions of war. The main advantage of a collapsing tap is that the necessity for reversing the direction of rotation to withdraw the tap is avoided, so that a considerable saving in time is effected, and there is less strain on the machine; better work is also produced, since with solid taps the thread is often damaged by swarf while the tap is being backed out of the hole. At the same time it is, of course, essential that these advantages should not be secured at the expense of accuracy, and that the mechanism employed should be as strong and simple as possible.

All these considerations appear to have been borne in mind in designing the tap illustrated herewith, which is made by the Murchey Machine and Tool Company, of Detroit, Mich., U.S.A., and is sold in this country by the Coats Machine Tool Company, Limited, of Caxton House, Westminster, S.W. The tap shown is intended for use on turret lathes, boring-mills, &c., in which the work is rotated and the tap has a longitudinal movement only; a slightly modified form is, however, made for use on drilling and tapping-machines in which the tap rotates and the work is stationary. The tap consists of a mild-steel body having slots at one end, which are hardened, and the chasers are free to slide radially in the slots, though they are prevented from moving in a longitudinal direction by a plate screwed on to the end of the body. The inner side of each of the chasers—that is, the side opposite the cutting edge—is stepped near its centre, so that the part nearest the left-hand end of the tap, as seen in Fig. 1, and the right-hand end, as seen in Figs. 2 and 3, is wider, measured in a radial direction, than the part nearer the shank of the body by an amount slightly exceeding the depth of the thread; the two parallel faces thus formed on the back of the chaser are joined by a short inclined plane.

Inside the body of the tap is a hardened-steel pin, shown dotted in Fig. 3, capable of sliding in an axial direction, and the inner sides of the chasers are kept in contact with this pin by a spring lettered *c*, in Figs. 3 and 5. This spring is an ordinary helical spring with its two ends joined to form a ring, and fitted into slots cut in the ends of the chasers. By means of a rod *d* passing through a slotted hole in the body of the tap, as shown in Fig. 4, the central pin is connected to a sleeve sliding on the outside of the body, and this sleeve is connected by two side rods to a ring lettered *a*, in Figs. 2 to 5, and clearly shown in the photographic illustration, Fig. 1.

Before commencing work the central pin is pressed into the space between the wider parts of the chasers by a knurled lever *b*, thus forcing the chasers radially outwards into the cutting position. The ring *a* is then adjusted by means of grub-screws in the ends of the rod *d* bearing on flats on the side rods, so that when the tap has entered the hole to the required depth the ring comes into contact with the face of the work. Any further movement between the tap and the work causes the ring and sleeve to be pushed back and thus withdraws the central pin into the space between the narrow parts of the chasers, thereby permitting the latter to be drawn radially inwards by the spring. The tap can then be withdrawn from the hole and the chasers reset by the lever *b*, ready for tapping the next hole. A slight adjustment is provided to compensate for the effect of grinding the chasers and to enable threads to be cut for a tight or easy fit. This is accomplished by splitting the central pin along two diameters for a part of its length and fitting a small conical pin into the end. By screwing in this pin the part of the central-pin on which the chasers bear when in their working position can be increased by a small fraction of an inch for the purpose mentioned.

The chasers, which are made of either high-speed or carbon steel, are formed by a hobbing process, and are slightly relieved to give the proper amount of clearance in cutting and to ensure accurate lead. They are easily taken out for grinding by removing the end plate, which is held in place by four screws, as shown in Fig. 5; grinding, it should be mentioned, does not in any way affect the lead. The taps are supplied in various sizes for tapping 1-in. to 12 in. holes, and by employing extra sets of chasers a single tap can be used for several different-sized holes. The only difference between the type of tap illustrated and the rotating type for use on drilling and tapping-machines is that, in the latter type, a Morse-taper shank is used in place of the cylindrical shank, and the hand-lever for setting the chasers is replaced by a flange-ring formed on the sliding-sleeve; the chasers are, in this case, reset by a stationary lever pressing on the flange-ring.

If desired, the taps can be combined with reaming, facing, and boring-cutters, and, by this means, manufacturing costs can frequently be reduced considerably. Collapsing taps for cutting the taper threads used in pipework are also made by the Murchey Company, and another of their products is a tap specially designed for use on automatic machines. In the latter type no tripping-ring is used, the chasers

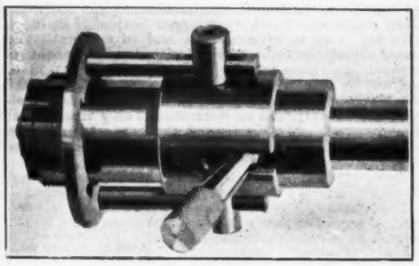
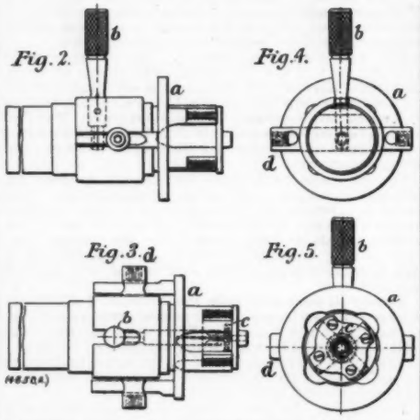


FIG. 1.



being arranged to collapse automatically as soon as the travel of the turret is stopped; they are reset by means of a handle coming into contact with a stop on the machine. This arrangement prevents the damage which would otherwise occur from the hole not being of the requisite depth, a circumstance which might arise from the stock not having been properly fed.

THE COMPOSITION OF THE EXHAUST FROM LIQUID-FUEL ENGINES.*

By Second-Lieut. ROBERT W. FENNING, R.E. (T.), B.Sc., D.I.C., of London.

IN the more elaborate tests on internal-combustion engines it is becoming the practice to analyse samples of the exhaust gases, with the object of determining the completeness of combustion and the probable strength of the air-fuel mixture supplied to the engine. The mixture strength, however, cannot be estimated from a partial exhaust-gas analysis alone, but considered in conjunction with an "exhaust-gas chart" the estimation is a simple matter.

The author has ventured to give the name of "exhaust-gas chart" to the set of curves obtained by plotting on a "strength of mixture" base, the percentages of carbon dioxide (CO_2), carbon monoxide (CO), and oxygen (O_2) in the exhaust gases, the strength of mixture being expressed as the ratio of air to fuel, by weight. Thus, if an engine be supplied with air-fuel mixtures of differing but known strengths, and the exhaust products from each mixture be analysed to determine the percentages of CO_2, O_2, and CO contained therein, and if these percentages be plotted against the ratio of air to fuel in the mixture, an exhaust-gas chart such as that shown by the curves marked CO_2, O_2, and CO in Fig. 3 (page 291) is obtained.

A more complete analysis of the exhaust products renders possible the addition of a curve showing the percentage of the hydrogen constituent, but this H_2 curve is not required for the estimation of mixture strength. Considering Fig 3, and omitting for the present the H_2 curve, it will be observed that the amounts of the CO_2, O_2, and CO constituents bear a definite relation to the mixture strength. That being the case, a partial analysis (for CO_2, O_2, and CO) of the engine exhaust, together with an exhaust-gas chart for the fuel used, are the only requisites for the estimation of the ratio of air to fuel in the mixture supplied to the engine.

Supposing an engine running on hexane, for example, gives an exhaust containing 13 per cent. of CO_2, 2.05 per cent. of O_2, and 0.0 per cent. of CO, the mixture strength, from Fig. 3, would be 17 parts by weight of air to 1 of fuel; whereas if the percentage of CO_2 be the same, but that of O_2 be 0.0 per cent., and of CO 2 per cent., the mixture strength would be 14.45 to 1. In the first case combustion is complete—in fact, there is more oxygen than is necessary for complete combustion; but in the second case combustion is incomplete, due to insufficient air in the original mixture. The strongest mixture giving complete combustion is clearly shown to be 15.3 to 1. Similar remarks apply to the petrol exhaust-gas chart and the benzene chart [to be given later].

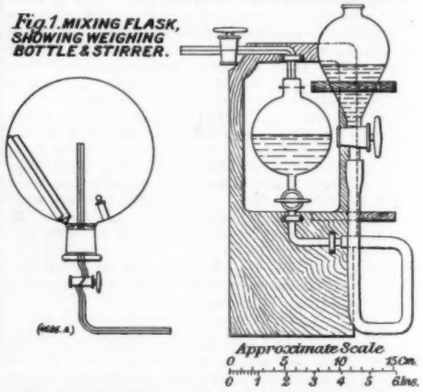
As far as the petrol engine is concerned, much valuable original work has already been done by Professor W. Watson, D.Sc., F.R.S., &c., in his tests on the four-cylinder Clement-Talbot and other engines.* Dr. Watson made direct measurements of the air and the petrol supplied to the engine, and also analysed the exhaust gases, and was thus able to construct an exhaust-gas chart for an engine using petrol.

In more recent work† Dr. Watson, in conjunction with others (Messrs. Frost, Lloyd, Richards, Stern, Shaw, and Wilson), has furnished exhaust-gas charts for benzol and alcohol. Many kinds of motor spirit are now obtainable, each fuel and each brand of the same fuel having most probably a different form of exhaust gas chart.

Object of Paper.—The object of the present paper is twofold: first, to describe a method of constructing exhaust-gas charts for suitable fuels without the use of an engine, and to set out the results of numerous experiments relating thereto; and, second, to increase the evidence as to the composition of exhaust gases, especially with reference to the combustible products obtained when using strong mixtures. Several exhaust-gas charts have been prepared, but it should be noted at once that such charts cannot be applied directly to cases in which

Fig. 2. EXPLOSION-VESSEL.

Fig. 1. MIXING FLASK, SHOWING WEIGHING BOTTLE & STIRRER.



the engine-exhaust is diluted with unburnt charge or air, as in some types of two-cycle engines.‡

The investigation was undertaken at the suggestion of Dr. Watson, who, some years ago, did some preliminary work of this nature, but had to abandon it for want of time. The author is much indebted to Dr. Watson for permission to use his apparatus, and for instruction in the use of it, and for many valuable suggestions.

Outline of Experiments.—Briefly, the experiments consisted in the preparation of mixtures of air and vaporised fuel in known proportions, the explosion of some of the mixture in a small explosion vessel, and the complete analysis of the resulting products of the combustion. Exhaust samples were also taken from an engine fitted with Dr. Watson's apparatus for measuring air and fuel, and these samples were analysed. Comparisons were then made between the composition of the products of combustion resulting from explosions in a small explosion vessel and in the actual engine.

Fuels Used.—Various fuels were employed, the considerations affecting their choice being:—(*a*) their volatility; (*b*) their suitability for motor spirit; and (*c*) their purity. Those selected were hexane (C_6H_{14}), and benzene (C_6H_6) as standard fuels; petrol (Bowley's Special) and commercial benzol as commercial fuels. The choice of a high-grade petrol, such as Bowley's Special, renders a comparison possible with the hexane results.

Preparation of Air-Fuel Mixture.—Considerable difficulty was experienced by the author in the preparation of mixtures of air and fuel in known ratios. Modifications to the mixing apparatus were made from time to time, and a very large number of early experimental results had to be abandoned and the work done again. In its final form, the apparatus consisted of a short-necked spherical flask of from 5 to 8 litres (8.8 to 14.1 pints) capacity, provided with a cork, carrying a glass capillary tube and plug-cock. To render the cork gas-tight, its ends were coated with shellac varnish and its sides with soap. Further, about 20 cub. cm. of mercury were placed in the flask, with the main idea of providing a seal over the cork on inverting that vessel. The flask was furnished with a stirrer, composed of a piece of thin corrugated iron, and was carefully calibrated. For diagram of flask, &c., see Fig. 1.

In preparing the mixture, air was blown into the flask

* Paper read before the Institution of Mechanical Engineers, March 17, 1916.

* Proceedings of the Institution of Automobile Engineers, vol. iii., pages 418 to 426, 1908-9.

† *Ibid.*, 1914-15.

‡ *Ibid.*, vol. v., pages 88 to 90, 1910-11.

far some minutes to drive out all traces of the previous charge. In due course the temperature of the air in the flask was observed, and the barometric height noted, two readings rendering possible the calculation of the weight of air in the flask, assuming the air to be dry. The humidity was not measured in the explosion-vessel tests, but only in the engine trials. The next operation was the introduction of a known weight of fuel. The fuel was weighed in a small glass weighing-bottle provided with a glass stopper. The bottle was then suspended from the capillary tube, on the inside of the cork, by means of two thin silk cords, and the cork inserted in position in the neck of the flask. The lengths and points of attachment of the cords were so arranged that on inclining the flask the stopper of the weighing-bottle was withdrawn, setting the fuel free.

After the evaporation of the fuel, the mixing of vapour and air was assisted by movements given to the mercury and the stirrer within the flask. This mechanical mixing process was continued for 10 minutes or more. The flask was then left in an inverted position for about 40 minutes, after which stirring was again resorted to for some minutes before the mixture was sampled. Stirring took place between each sampling. From 5 to 8 litres of mixture were thus prepared—mixture of known composition and at a pressure greater than the atmosphere, due to the formation of the fuel vapour. So long as this natural positive pressure existed, the taking of samples of the mixture was an easy matter; afterwards the flask had to be heated.

Explosion of Mixture.—The required volume of the explosive mixture was passed from the mixing flask into the burette of a Macfarlane and Caldwell gas-analysis apparatus, mercury displacement being used. After measurement in the burette, the mixture was passed into a glass explosion vessel, Fig. 2, in which mercury displacement was also used. The mixture was then ignited by the passage of a high-tension spark, and the gaseous products of combustion drawn back into the burette and measured. The products were then ready for analysis, but before describing that process one or two important details must be mentioned.

The presence of rubber was found to have a weakening effect on all the air-fuel mixtures, benzol mixture being largely affected, petrol considerably, and hexane slightly. The employment of rubber was therefore limited to one connection only—the connection between the abutting capillary tubes of the flask and burette or the explosion vessel and burette—and in this case the inside of the rubber tube was coated with soap.

The pressure of the mixture before explosion varied from a few centimetres of mercury above atmosphere to a few below, its amount being regulated to suit the strength of mixture. With weaker mixtures the higher pressure was employed to secure satisfactory ignition. Further, in some cases the explosion took place at constant volume, the lower cock of the explosion vessel being closed, whereas in other cases this cock was left open to limit the risk of bursting the vessel. Before each explosion, a wooden cover, provided with a sight-hole, was placed over the explosion vessel, but in no case was the vessel fractured. The nature of the flame, as to colour, &c., was observed.

Volume of the Mixture Exploded.—The volume exploded was either about 50 cub. cm. or double that quantity. The smaller volume was measured before and after explosion, to obtain the alteration in volume, the change in volume including that due to the condensation of the steam. The larger volume was very roughly determined before explosion only, the object being to have sufficient products available to provide for a check on the analysis.

Use of Oxy-Hydrogen Gas.—Under the given conditions of explosion several of the weaker mixtures would not fire without the addition of a small quantity—from 6 to 14 per cent.—of oxy-hydrogen gas. Mixtures weaker than about 16 or 17 to 1 seemed to require this addition. The gas, of course, entirely disappears on explosion, and therefore has no influence on the subsequent analysis. Some of the processes in the analysis also required the production of combustion or explosion, and for this purpose oxy-hydrogen gas was again employed, the quantity

TABLE I.—AIR-HEXANE MIXTURES.

Sample No.	Air / Hexane by Weight.	Volume in Cub. Cm. of Mixture Exploded.	Alteration in Volume, as a Percentage of Volume of Mixture.†	Results of Analyses of Products, expressed as a Percentage of Volume of Products of Combustion. CO_2.	O_2.	Heavy Hydrocarbons.	CO.	Air or O_2 Added to Remnant Gases, and Mixture Exploded. Alteration in Volume.	Air or O_2 Added to Remnant Gases, and Mixture Exploded. CO_2 Formed	Air or O_2 added to Remnant Gases, Mixture Passed through Palladium Tube and then Exploded. H_2 by Palladium.	Alteration in Volume on Explosion.	CO_2 Formed	Some of Original Products Taken; Air or O_2 Added and Mixture Exploded. Volume in Cub. Cm. of Products.	By Measurement. Alteration in Volume in Cub. Cm. on Explosion.	CO_2 Absorbed in Cub. Cm.	By Calculation from Analysis. Alteration in Volume in Cub. Cm.	CO_2 in Cub. Cm.	Calculation from Analysis of Products. Air / Hexane	H_2 by Volume in Products of C_2 by Volume	REMARKS.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	
245	8.93	45.4	+7.4	5.3	0.1	—	14.3	-13.8	0.8	—	—	—	—	—	—	—	—	—	—	Yellow tongues of flame.
246		45.8	+7.3	5.4	0.1	—	14.3	—	—	8.7	-0.6	0.8	—	—	—	—	—	—	—	Yellow tongues of flame; green on top.
247		100*	—	5.3	0.1	0.2	14.1	—	—	9.4	-0.2	0.5	42.6	- 9.8	8.6	- 9.8	8.6	8.87	2.30	Ditto Ditto
248	9.05	45.8	+6.8	5.5	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
249		100*	—	5.5	0	0.1	13.9	—	—	9.1	-0.1	0.2	42.8	- 9.6	8.6	- 9.1	8.5	9.19	2.30	
255	10.30	47.8	+1.9	6.9	0	—	11.6	- 9.1	0.2	—	—	—	—	—	—	—	—	—	—	
257		100*	—	7.2	0	0.1	11.4	—	—	6.3	0	0.2	44.1	- 7.1	8.2	- 6.9	8.4	10.13	2.20	Blue flame; large red centre.
250	11.53	100*	—	8.7	0	0	8.7	—	—	3.9	+0.2	0.2	43.9	- 4.7	7.7	- 4.7	7.7	11.42	2.27	Bluish-white flame; red near ignition point.
251		49.7	-2.2	8.7	0	—	8.9	- 5.8	0.2	—	—	—	—	—	—	—	—	—	—	
252		50.0	-6.7	11.5	--	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
253	13.41	49.8	-6.8	11.3	0.1	—	4.4	- 2.0	0.2	—	—	—	—	—	—	—	—	—	—	Bluish-white flame; red centre.
254		100*	—	11.6	0	0.1	4.5	—	—	1.5	0	0.1	45.0	- 2.1	7.1	- 2.2	7.4	12.98	2.30	
258	14.97	49.8	-9.2	13.7	0	—	0.7	—	—	0.2	+0.1	0	—	—	—	—	—	15.02	2.43	White flame; yellow centre.
259		49.8	-9.2	13.8	0	—	0.8	—	—	—	—	—	—	—	—	—	—	—	—	
260	16.84	50.0	-8.9	13.2	1.9	—	0	—	—	—	—	—	—	—	—	—	—	16.46	2.27	Oxy-hydrogen gas added to mixture.
261		49.8	-8.9	13.1	1.9	—	0	—	—	—	—	—	—	—	—	—	—	16.55	2.32	Ditto Ditto
262	18.91	49.6	-8.2	11.7	3.8	—	0	—	—	—	—	—	—	—	—	—	—	18.33	2.40	Ditto Ditto
263		49.8	-8.0	11.7	3.9	—	0	—	—	—	—	—	—	—	—	—	—	—	—	Ditto Ditto
264	20.93	49.8	-7.2	10.7	5.6	—	0	—	—	—	—	—	—	—	—	—	—	20.06	2.24	Ditto Ditto

* Approximate values. † The alteration in volume includes that due to the condensation of the steam.

TABLE II.—AIR-PETROL MIXTURES. (BOWLEY'S SPECIAL—SAMPLE A.)

Sample No.	Air / Petrol by Weight.	Volume in Cub. Cm. of Mixture Exploded.	Alteration in Volume, as a Percentage of Volume of Mixture.†	Results of Analyses of Products, expressed as a Percentage of Volume of Products of Combustion. CO_2.	O_2.	Heavy Hydrocarbons.	CO.	Air or O_2 Added to Remnant Gases and Mixture Exploded. Alteration in Volume	Air or O_2 Added to Remnant Gases, Mixture Passed Through Palladium Tube and then Exploded. CO_2 Formed	H_2 by Palladium.	Alteration in Volume on Explosion.	CO_2 Formed	Some of Original Products Taken; Air or O_2 Added and Mixture Exploded. Volume in Cub. Cm. of Products.	By Measurement. Alteration in Volume in Cub. Cm. on Explosion.	CO_2 Absorbed in Cub. Cm.	By Calculation from Analysis. Alteration in Volume in Cub. Cm.	CO_2 in Cub. Cm.	Calculation from Analysis of Products. Air / Petrol	H_2 by Volume in Products of Combustion. C_2 by Volume	REMARKS.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	
232	8.99	46.4	+ 6.3	5.6	0.2	—	13.9	—	—	8.1	- 0.5	0.5	—	—	—	—	—	—	—	
233		46.2	+ 6.5	5.7	0	—	14.1	- 13.2	0.7	—	—	—	—	—	—	—	—	—	—	Yellow tongues of flame with grenish top.
234		100*	—	5.6	0	0.3	14.1	—	—	8.8	- 0.2	0.4	40.7	- 8.8	8.3	- 8.8	8.4	8.87	2.17	
207	10.14	48.3	+ 1.8	7.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Bromine used.
208		48.5	+ 1.7	7.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Ditto
227	10.89	47.8	- 0.5	8.0	0	—	10.2	—	0.2	—	—	—	—	—	—	—	—	—	—	Bluish flame; red near ignition point.
228		100*	—	8.0	0	0	9.6	—	—	—	- 0.2	0.2	—	—	—	—	—	—	—	Ditto Ditto
229		48.9	- 0.6	7.9	0.2	—	10.0	—	—	—	- 0.1	0.3	—	—	—	—	—	—	—	Ditto Ditto
235	11.06	49.2	- 1.3	8.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
236		49.8	- 1.3	8.2	0.2	—	9.6	- 6.6	0.3	—	—	—	—	—	—	—	—	—	—	Ditto Ditto
237		100*	—	8.5	0.1	0.1	9.5	—	—	4.4	0	0.2	44.2	- 5.4	8.0	- 5.3	7.8	10.86	2.11	Ditto Ditto
239	12.81	49.8	- 5.6	10.9	0.1	—	5.5	- 2.8	0	—	—	—	—	—	—	—	—	—	—	Bluish-white flame; red near ignition point
340		49.8	- 5.7	11.0	0	—	5.4	—	—	1.8	0	0.2	—	—	—	—	—	—	—	
241		100*	—	10.8	0	0	5.4	—	—	1.9	0	0.1	45.6	- 2.8	7.6	- 2.6	7.5	12.82	2.30	Ditto
230	12.81	49.8	- 5.7	11.1	0	—	5.2	—	0.3	—	—	—	—	—	—	—	—	—	—	Ditto
231		50.0	- 5.9	11.1	0.2	—	5.3	—	—	1.8	—	—	—	—	—	—	—	—	—	Ditto
223	14.63	49.8	- 8.5	13.8	—	—	1.4	—	—	—	—	—	—	—	—	—	—	—	—	Bluish flame; red near ignition point.
242	14.97	49.8	- 9.3	14.3	0.1	—	0.3	—	—	0	+ 0.1	0.1	—	—	—	—	—	—	—	
243		49.8	- 9.2	14.2	0.2	—	0.3	—	—	—	—	—	—	—	—	—	—	15.09	2.25	White flame; yellow near ignition point.
221	15.90	50.1	- 9.0	13.9	1.0	—	0	—	—	—	—	—	—	—	—	—	—	15.73	2.22	
222		49.8	- 9.0	13.9	1.0	—	0	—	—	—	—	—	—	—	—	—	—	15.73	2.22	Oxy-hydrogen gas added to mixture.
219	17.88	49.6	- 8.1	12.4	3.3	—	0	—	—	—	—	—	—	—	—	—	—	17.52	2.18	Ditto Ditto
220		49.8	- 8.2	12.4	3.3	—	0	—	—	—	—	—	—	—	—	—	—	17.52	2.18	Ditto Ditto
217	20.05	49.8	- 7.3	11.2	5.1	—	0	—	—	—	—	—	—	—	—	—	—	19.31	2.14	Ditto Ditto
218		49.6	- 7.5	11.1	5.0	—	0	—	—	—	—	—	—	—	—	—	—	19.53	2.25	Ditto Ditto
215	22.05	50.0	- 6.8	10.1	6.4	—	0	—	—	—	—	—	—	—	—	—	—	21.15	2.28	Ditto Ditto
216		49.8	- 6.7	9.9	6.5	—	0	—	—	—	—	—	—	—	—	—	—	21.45	2.38	Ditto Ditto

* Approximate values. † The alteration in volume includes that due to the condensation of the steam.

being regulated according to the amount of combustible gas already present. The electrolytic gas has to be used with discretion, since too much causes a high temperature explosion, with the possible formation of oxides of nitrogen, and the resulting contraction in volume cannot be interpreted.

Too small a quantity, however, gives incomplete combustion and equally misleading results. Separate

It can be concluded, therefore, that satisfactory results would be secured by the addition to the incombustible gases of from $\frac{1}{4}$ to $\frac{1}{3}$ of their volume of oxy-hydrogen gas. The gas, obtained by the electrolysis of water, was usually exposed to the action of daylight for 10 or 12 hours before use, in order to break up any ozone that might be present. In the experiments quoted above, and in some other cases, the oxy-hydrogen gas was drawn from the

about eleven pipettes were required for a complete analysis.

(*c*) *Method of Procedure.*—The products of combustion of strong mixtures contain combustible gases, and it is the estimation of these gases which makes the analysis so elaborate. The following is a typical treatment of such a mixture and its products. At least two samples were drawn from the mixing-flask, the second sample

TABLE III.—AIR-PETROL. ENGINE-EXHAUST SAMPLES.

Sample No.	Air / Petrol by Weight.	Volume in Cub. Cm. of Mixture Exploded.	Results of Analyses of Products, expressed as a Percentage of Volume of Products of Combustion. CO_2	O_2	Heavy Hydrocarbons.	CO.	Air or O_2 Added to Remnant Gases, and Mixture Exploded. Alteration in Volume	Air or O_2 Added to Remnant Gases, and Mixture Exploded. CO_2 Formed	Air or O_2 Added to Remnant Gases, Mixture Passed Through Palladium Tube and then Exploded. H_2 by Palladium.	Alteration in Volume on Explosion.	CO_2 Formed	Some of Original Products Taken; Air or O_2 Added and Mixture Exploded. Volume in Cub. Cm. of Products.	By Measurement. Alteration in Volume in Cub. Cm. on Explosion.	CO_2 Absorbed in Cub. Cm.	By Calculation from Analysis. Alteration in Volume in Cub. Cm.	CO_2 in Cub. Cm.	Air / Petrol by Calculation from Analysis of Products.	H_2 by Volume in Products of O_2 by Volume	REMARKS.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	
272 A	10.32*	Sleeve-valve engine: cylinder 10½ × 120 mm.	7.1	0.5	0.2	10.8	—	—	5.7	−0.2	0.2	—	—	—	—	—	10.30	2.19	
	10.32*		7.2	0.5	—	11.0	−9.5	0.7	—	—	—	42.4	−6.6	8.0	−6.3	7.9	—	—	
268 B	12.04*		9.6	0.2	0	7.2	—	—	3.4	−0.1	0.2	—	—	—	—	—	11.97	2.26	Bowley's Special—Sample A.
	12.04*		9.7	0.4	—	7.1	−5.5	0.5	—	—	—	45.2	−4.2	7.8	−4.1	7.7	—	—	
269 C	12.73*		10.7	0.3	0.2	5.6	—	—	2.4	−0.1	0.2	—	—	—	—	—	12.27	2.21	* Air / Petrol ratio estimated from analysis curves, Figs. 4 and 5 [to be given later.]
	12.73*		10.8	0.4	—	5.6	−4.1	0.3	—	—	—	45.6	−3.2	7.5	−3.3	7.7	—	—	
271	12.80*		10.8	0.4	0.1	5.4	−3.6	0.1	—	—	—	—	—	—	—	—	—	—	
270 D	12.97*		11.2	0.3	0	5.1	—	—	2.0	0	0.1	—	—	—	—	—	12.83	2.11	
	12.97*		11.2	0.3	—	5.1	−3.5	0.4	—	—	—	45.2	−2.7	7.5	−2.6	7.4	—	—	
276 E	12.87*		11.1	0.2	—	5.5	—	—	2.3	0.3	0.2	—	—	—	—	—	—	—	
	12.87*		11.1	0.2	—	5.5	−3.7	0.3	—	—	—	44.5	−2.9	7.5	−3.0	7.5	—	—	
277 F	13.90*		12.5	0.4	—	2.7	—	—	1.1	0.1	0.3	46.1	−1.3	6.3	−1.5	6.3	13.74	2.25	Bowley's Special—Sample B.
273 G	16.34*		13.3	1.4	—	0	—	—	—	—	—	—	—	—	—	—	—	—	
	16.34*		13.4	1.4	—	0.2	—	—	—	—	—	—	—	—	—	—	16.01	2.26	* Air / Petrol ratio estimated from analysis curves, Figs. 4 and 5 [to be given later].
274 H	16.96*		13.4	1.4	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	
	16.96*		12.9	2.1	—	0.1	—	—	—	—	—	—	—	—	—	—	16.66	2.34	
275 J	19.76*		13.0	2.2	—	0.2	—	—	—	—	—	—	—	—	—	—	16.51	2.18	
	19.76*		11.2	4.9	—	0.1	—	—	—	—	—	—	—	—	—	—	19.11	2.18	
			11.2	4.8	—	0	—	—	—	—	—	—	—	—	—	—	19.21	2.27	
278	11.09		8.1	0.5	—	9.2	—	—	—	—	—	—	—	—	—	—	—	—	Bowley's Special—Sample C.
279	11.98		9.6	0.4	—	7.1	—	—	—	—	—	—	—	—	—	—	—	—	Air / Petrol ratio measured by actually measuring weights of air and petrol supplied to engine. Dr. Watson's method.
280	14.23		13.0	0.2	—	2.1	—	—	—	—	—	—	—	—	—	—	—	—	
281	15.56		14.0	0.7	—	0.2	—	—	—	—	—	—	—	—	—	—	15.43	2.20	
282	17.29		12.7	2.5	—	0.1	—	—	—	—	—	—	—	—	—	—	16.94	2.26	
283	19.15		11.2	4.5	—	0.2	—	—	—	—	—	—	—	—	—	—	18.82	2.32	

* Approximate Values.

TABLE IV.—AIR-BENZINE MIXTURES.

Sample No.	Air / Benzine by Weight.	Volume in Cub. Cm. of Mixture Exploded.	Alteration in Volume, as a Percentage of Volume of Mixture.†	Results of Analyses of Products, expressed as a Percentage of Volume of Products of Combustion. CO_2	O_2	Heavy Hydrocarbons.	CO.	Air or O_2 Added to Remnant Gases, and Mixture Exploded. Alteration in Volume	Air or O_2 Added to Remnant Gases, and Mixture Exploded. CO_2 Formed	Air or O_2 Added to Remnant Gases, Mixture Passed Through Palladium Tube and then Exploded. H_2 by Palladium.	Alteration in Volume on Explosion.	CO_2 Formed	Some of Original Products Taken; Air or O_2 Added and Mixture Exploded. Volume in Cub. Cm. of Products.	By Measurement. Alteration in Volume in Cub. Cm. on Explosion.	CO_2 Absorbed in Cub. Cm.	By Calculation from Analysis. Alteration in Volume in Cub. Cm.	CO_2 in Cub. Cm.	Air / Benzine by Calculation from Analysis of Products.	H_2 by Volume in Products of O_2 by Volume	REMARKS.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	
317	8.07	44.15	+5.0	7.6	0	—	16.0	—	—	—	—	—	—	—	—	—	—	—	—	Bright yellow flame.
318		100*	—	7.1	0.1	0.15	16.5	—	—	5.0	+0.3	0	42.2†	−7.15	10.35	−6.8	10.3	8.16	1.02	Exploded without the addition of oxy-hydrogen gas.†
319		46.8	+5.1	7.5	0.2	—	15.9	—	—	—	—	—	—	—	—	—	—	—	—	
320	9.44	48.8	+0.45	10.2	0	—	11.4	—	—	—	—	—	—	—	—	—	—	—	—	Blue-white flame; large yellow centre.
321		100*	—	10.0	0	trace	11.7	—	—	2.8	−0.1	0	41.7	−4.55	9.3	−4.25	9.16	9.61	1.04	Ditto
315	10.80	44.0	−2.95	13.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Blue flame; not very vigorous.
316		100*	—	12.8	0	trace	7.2	—	—	1.4	—	0	—	—	—	—	—	10.85	1.03	
322	12.17	50.0	−5.8	15.7	0	—	2.4	—	—	—	—	—	—	—	—	—	—	—	—	Blue-white flame; whiter at centre.
323		100*	—	15.3	0.1	—	3.0	—	—	0.6	0	0	40.3	−1.05	7.6	−0.95	7.4	12.35	1.10	Blue-white flame; red centre.
306	13.25	50.0	−6.7	17.2	0.2	—	0.2	—	—	—	—	—	—	—	—	—	—	13.28	1.02	White flame.
307		50.0	−6.8	17.2	0.2	—	0.2	—	—	—	—	—	—	—	—	—	—	13.28	1.02	White flame; yellow near ignition point.
324	14.80	49.9	−6.1	15.2	2.6	—	0	—	—	—	—	—	—	—	—	—	—	—	—	Blue flame; large yellow centre.
325		100*	—	15.7	2.1	—	0	—	—	—	—	—	—	—	—	—	—	14.67	1.05	Light purplish-blue flame; yellow centre.
326	16.82	100*	—	13.7	4.4	—	0.1	—	—	—	—	—	—	—	—	—	—	16.59	1.06	Yellow flame; bluish outside.
327		49.9	−5.5	13.6	4.6	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	Did not fire readily.
328	19.05	100*	—	12.4	5.9	—	0	—	—	—	—	—	—	—	—	—	—	18.35	1.11	Oxy-hydrogen gas used.
329		49.8	−5.0	12.4	6.1	—	0	—	—	—	—	—	—	—	—	—	—	18.43	1.03	Ditto.
330	20.86	49.8	−4.8	11.4	7.2	—	0	—	—	—	—	—	—	—	—	—	—	19.94	1.09	Ditto.
331		49.8	−4.5	11.1	7.5	—	0	—	—	—	—	—	—	—	—	—	—	20.43	1.12	Ditto.

* Approximate values.

† The alteration in volume includes that due to the condensation of the steam.

experiments, undertaken to ascertain the correct quantity, gave the following results:—

Experiment.	Volume of air in cub. cm.	Volume of air plus oxy-hydrogen gas.	Oxy-hydrogen gas. / Air.	Volume after explosion.	Remarks.
			per cent.		
1	44.85	49.8	11.0	49.0	Explosions not perceived.
2	41.85	49.85	19.1	41.95	Flame scarcely perceived.
3	40.0	49.95	24.9	40.0	More vigorous explosion.
4	38.0	50.0	31.6	38.0	Still more vigorous explosion.

The agreement of columns 2 and 5 indicates complete combustion without the formation of oxides of nitrogen.

generator at too brief intervals to permit of the daylight action taking proper effect.

ANALYSIS OF PRODUCTS OF COMBUSTION.

(*a*) *Apparatus.*—The Macfarlane and Caldwell apparatus was used throughout and found to give results to a considerable degree of accuracy. With mercury as the displacing fluid, the volume of gas in a 50 cub. cm. burette can easily be read to 0.1 cub. cm., and was usually estimated to 0.05 cub. cm. The variation in the shape of the mercury meniscus affects the accuracy slightly.

(*b*) *Absorbents, &c.*—Caustic potash solution was used for the absorption of carbon dioxide, alkaline pyrogallol solution for oxygen, hydrochloric acid solution of cuprous chloride for carbon monoxide, and fuming sulphuric acid for the heavy hydrocarbons. Hydrogen was estimated by fractional combustion, a glass tube containing palladium sponge—hereafter referred to as the palladium tube—being employed for the purpose. Altogether

being taken from 1 to 3 hours after the first:—The first sample, of about 50 cub. cm., was measured before and after explosion, and the alteration in volume observed. The products were then analysed, using operations 2, 3, 7, 8, 10, 11, 12, 14, 15, and 16, of the list of operations set out below. No fuming sulphuric acid was used, and therefore the heavy hydrocarbons, if any, were absorbed by the cuprous chloride solution, and thus included in the estimation of the carbon monoxide. Further, the alteration in volume in operation 14 was due to the combustion of H_2, CH_4, &c.

The second sample, of about 100 cub. cm., was not measured before or after explosion, but its products of combustion were divided into two parts, the first portion subjected to operations 1 to 16 and the second to operations 18 to 22. The calculation is given to show how the results of operations 20 and 21 are used to check those of 1 to 16. With weak mixtures the products of combustion contained no combustible gases, and therefore operations 1, 2, 3, 7, and 8 only were necessary.

Method of Analysis.

$\frac{\text{Air}}{\text{Hexane}} = 11.53$—about 100 cub. cm. of mixture exploded—bluish-white flame, red near ignition point.

	Operation.	Burette reading.	Result.
1	Some of products drawn into burette and measured	49.95	—
2	Passed into KOH, and returned to burette	45.6	$CO_2 = 4.35 \times \frac{100}{49.95} = 8.70$ per cent.
3	Passed into alkaline pyrogallol and returned	45.6	$O_2 = 0$
4	Passed into fuming sulphuric acid and returned	45.6	Heavy Hydrocarbons = 0
5	Passed into caustic potash and returned		
6	Passed into alkaline pyrogallol to remove the O_2 introduced when using the fuming sulphuric acid and returned	45.55	—
7	Passed into cuprous chloride No. 1 and returned	41.2	$CO = 4.35 \times \frac{100}{49.95} = 8.70$ per cent.
8	Passed into cuprous chloride No. 2 and returned		
9	Passed into caustic potash to neutralise acid fumes before using palladium sponge	41.2	—
10	Passed into water pipette, whilst burette was cleaned out	—	—
11	Drawn back into burette with slight loss	37.6	—
12	Air added to gases in burette	47.8	Air added = 10.2 cub. cm.
13	Passed through palladium tube four times—first time tube surrounded by water bath at atmospheric temperature—other times temperature of bath 100 deg. Cent.	45.1	$H_2 = 2.7 \times \frac{41.2}{37.6} \times \frac{100}{49.95} \times \frac{3}{2} = 3.9$ per cent.
14	Oxy-hydrogen gas added, and mixture exploded in explosion pipette and returned	45.2	Increase in volume = 0.2 per cent.
15	Passed into caustic potash and returned	45.1	$CO_2 = 0.2$ per cent., therefore $CH_4 = 0.2$ per cent.*
16	Passed into alkaline pyrogallol and returned	43.65	O_2 in excess.
17	Burette thoroughly cleaned	—	—
18	Some of the original products of combustion taken	43.9	—
19	O_2 (containing some nitrogen) added	49.0	—
20	Oxy-hydrogen gas added and mixture exploded and returned	44.3	Decrease = 4.7 cub. cm.
21	Passed into caustic potash and returned	36.6	$CO_2 = 7.7$ cub. cm.
22	Passed into alkaline pyrogallol and returned	34.8	O_2 in excess.

* *Vide* page 292.

Check: According to the analysis, 43.9 cub. cm. of products would contain:—

$0.439 \times 8.7 = 3.82$ cub. cm. of CO_2.
$0.439 \times 8.7 = 3.82$ cub. cm. of CO.
$0.439 \times 3.95 = 1.74$ cub. cm. of H_2.
$0.439 \times 0.2 = 0.09$ cub. cm. of CH_4.
$0.439 \times 0.0 = 0.0$ cub. cm. of C_2H_4 (heavy hydrocarbon).

After combustion:—

The CO_2 would be $3.82 + 3.82 + 0.09 = 7.73$ cub. cm
The contraction would be $1.91 + 2.61 + 0.18 = 4.70$ cub. cm.

The check analysis values, given in results 21 and 20 above, are 7.7 cub. cm. and 4.7 cub. cm. A reference to columns 15, 16, 17, and 18, of Table I. (page 289), and similar columns of Tables II., III., and IV. (pages 289 and 290), shows that the agreement is not always so close as in the example taken.

Engine Exhaust Samples.

It has already been mentioned that, for the purposes of comparison, samples of the exhaust gases from an engine were also analysed. The samples were taken from the exhaust of a single-cylinder sleeve-valve engine, 102 mm. diameter by 129 mm. stroke, running at 800 revolutions per minute.

(a) *Measurement of Strength of Mixture.*—The air and fuel supplied to the engine were measured separately by the method adopted by Dr. Watson in his tests of a four-cylinder Clement-Talbot and other engines.* The engine drew its air supply from a carefully constructed box provided with a thin metal plate perforated by an aperture of known area. Readings of the pressure difference on the two sides of the aperture, the barometric height, the temperature and hygrometric state of the air—used in conjunction with the aperture coefficient—gave sufficient data for the computation of the weight of air consumed per second. Knowing the density of the fuel for a considerable range of temperature, the weight of fuel consumed per second was calculated from observations of its temperature and the time taken by the carburettor to dispose of a volume of 300 cub. cm. During the time interval, varying from 3 minutes to 12 minutes, the sampling of the exhaust gases proceeded.

(b) *Analysis of Samples.*—A reference to Tables III. and V. (pages 290 and 291) will show the degree of the completeness of the analysis; no further details need be given.

(c) *Fuels Used.*—The fuels used in the engine tests were Bowley's special petrol and commercial benzol. A number of samples were also taken when the engine was running on methylated spirit. Details of these latter analyses are not given, but only such particulars as are required to show the relation between the hydrogen and carbon monoxide.

* Proceedings of the Institution of Automobile Engineers, vol. iii., pages 389 and 396; vol. v., page 87; and Proceedings of the Institution of Mechanical Engineers, 1912, page 517.

General Discussion of Results.

(a) *Air-Hexane Mixtures using Explosion Vessel.*—The results are set out numerically in Table I. (page 289), and graphically in Fig. 3, below, and in Figs. 8 and 9 [to be given later]. Hexane being a fuel of known composition, the strongest mixture giving complete combustion can be computed, its value being 15.24. The experimental value given by the exhaust-gas chart in Fig. 3 is about 15.3. Calculations of the composition of the products of weaker mixtures than that just dealt with can be made and used to check the accuracy of the chart, and it will be found that the calculated values of the CO_2 are somewhat lower, and of the O_2 somewhat higher, than the experimental ones, the discrepancy increasing with decrease in mixture strength.

Air/Hexane by Weight.	CO_2 per Cent. Experimental.	CO_2 per Cent. Calculated.	O_2 per Cent. Experimental.	O_2 per Cent. Calculated.	Contraction in Volume per Cent. Experimental.	Contraction in Volume per Cent. Calculated.
15.3	14.28	14.25	0	0	9.55	9.65
17.0	13.0	12.7	2.05	2.3	8.9	8.7
19.0	11.65	11.3	4.0	4.3	8.0	7.8
21.0	10.7	10.2	5.7	6.0	7.2	7.1

Had the calculated values for CO_2 been greater than the experimental, it would have been easy to explain the difference by assuming that some of the vapour in the original mixture had been absorbed, or that some constituent in the exhaust products containing carbon had not been detected. As it is, a reason for the discrepancy is not easy to find. Similar discrepancies with regard to CO_2 and O_2 occur in the benzene results. It must be noted that in computing the composition of the exhaust products no account has been taken of water vapour in the original mixture or in the products.

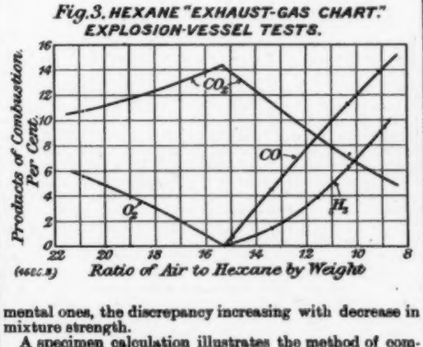
Turning to mixtures stronger than 15.3 to 1, it will be apparent that the method just given for estimating the composition of the products cannot be applied, since the relation between the combustible constituents (CO, H_2, CH_4, &c.) in the exhaust is not known, except by experiment. A check on the experimental results is provided, however, by calculating the mixture strength from the composition of the exhaust, and comparing the calculated and measured strengths.

Particulars of the method of calculation have already been given by Dr. Dugald Clerk* and more fully by Dr. W. Watson,† but to save reference a detailed calculation is set out.

TABLE V.—Air-Benzol. Engine-Exhaust Samples.

Sample No.	Air/Benzol by Weight.	Volume of Mixture Exploded.	Results of Analyses of Products, expressed as a Percentage of Volume of Products of Combustion. CO_2.	O_2.	Heavy Hydrocarbons	CO.	Air or O_2 Added to Remnant Gases, and Mixture Exploded. Alteration in Volume.	Air or O_2 Added to Remnant Gases, and Mixture Exploded. CO_2 Formed.	Air or O_2 Added to Remnant Gases, Mixture Passed Through Palladium Tube, and then Exploded. H_2 by Palladium.	Air or O_2 Added to Remnant Gases, Mixture Passed Through Palladium Tube, and then Exploded. Alteration in Volume on Explosion.	Air or O_2 Added to Remnant Gases, Mixture Passed Through Palladium Tube, and then Exploded. CO_2 Formed.	Air by Calculation from Analysis of Products. Air/Benzol	H_2 by Volume in Products of C_2 by Volume	Remarks.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	
287	7.98	Sleeve-valve engine: Cylinder 102 mm. by 129 mm.	6.1	0.8	0.15	16.75	—	—	5.2	+0.1 · · ·	0	8.35	1.09	Air ratio determined by actually measuring weights of air and benzol supplied to engine. Dr. Watson's method.
	7.98		6.2	0.8	0.25	16.7	−7.9	0.1	—	—	—	—	—	
288	8.88		8.5	0.7	0.3	13.15	—	—	3.65	—	0.2	8.71	1.07	
	8.88		8.5	0.7	—	13.55	—	—	—	—	—	—	—	
289	9.80		10.4	0.7	0	10.3	—	—	2.45	+0.2 · · ·	0	10.32	1.02	
	9.80		10.25	0.5	—	10.2	−3.7	0.1	—	—	—	—	—	
290	10.64		12.1	0.5	0.15	7.7	—	—	1.6	—	0.2	10.42	1.05	
291	11.47		13.6	0.7	—	5.0	—	—	1.0	+0.2 · · ·	0	—	—	
292	13.14		16.5	0.7	—	0.6	—	—	—	—	—	—	—	
293	10.23		11.2	0.7	—	9.3	—	—	—	—	—	—	—	
294	10.64		12.0	0.3	—	8.1	—	—	—	—	—	—	—	
295	12.23		15.3	0.3	—	3.1	—	—	—	—	—	—	—	
296	14.39		15.9	1.3	—	0.2	—	—	—	—	—	14.23	1.17	
297	17.39		12.9	5.0	—	0.1	—	—	—	—	—	17.48	1.18	
298	19.45		11.4	7.2	—	0	—	—	—	—	—	19.94	1.09	
238	10.74		12.7	0.2	0.1	7.1	—	—	1.5	0	0	10.77	1.03	

Fig. 3. HEXANE "EXHAUST-GAS CHART." EXPLOSION-VESSEL TESTS.



Now $2\,C_6H_{14} + 19\,O_2 = 12\,CO_2 + 14\,H_2O$,

i.e., 1 volume of hexane (vapour) combines with 9.5 volumes of O_2 to form 6 volumes of CO_2 and 7 volumes of steam.

Further, 50.7 volumes of dry air contain { 10.6 volumes of O_2 ; 40.1 ,, N_2.

Therefore, if 1 volume of hexane be burnt with 50.7 volumes of air, 6 volumes of CO_2 will be formed and 9.5 volumes of O_2 used, leaving $10.6 - 9.5 = 1.1$ volumes of free O_2. The nitrogen is unaffected and the steam condenses to an inappreciable volume of water.

The products of combustion will therefore consist of:—

CO_2	6.0 volumes	= 12.7 per cent.	of products of combustion.
O_2	1.1 ,,	= 2.3	Ditto
N_2	40.1 ,,	= 85.0	Ditto
Total products	47.2	100.0	

and the contraction in volume (the steam having been condensed) will be the original volume of air plus fuel (viz., 51.7 volumes), minus the volume of products, *i.e.*:—

$$51.7 - 47.2 = 4.5 = \frac{4.5 \times 100}{51.7} = 8.7 \text{ per cent.}$$

An interesting comparison of calculated values with experimental ones is given in the next column.

Turning to mixtures stronger than 15.3 to 1, it will be apparent that the method just given for estimating the composition of the products cannot be applied, since the relation between the combustible constituents (CO, H_2, CH_4, &c.) in the exhaust is not known, except by experiment. A check on the experimental results is provided, however, by calculating the mixture strength from the composition of the exhaust, and comparing the calculated and measured strengths.

Particulars of the method of calculation have already been given by Dr. Dugald Clerk* and more fully by Dr. W. Watson,† but to save reference a detailed calculation is set out.

Sample No. 247: $\frac{\text{Air}}{\text{Hexane}} = 8.93$ (by measurement).

Analysis.

	Per Cent.
CO_2 =	5.3
O_2 =	0.1
CO =	14.1
H_2 =	9.4
CH_4 =	0.5
C_2H_4 =	0.2
N_2 =	70.4 (by difference)
	100.0

Use this analysis to compute the volumes and weights of carbon and hydrogen (allowing for H_2 burnt to water) in the exhaust, and the weight of air originally associated with the nitrogen, and so determine the ratio of air to fuel (carbon and hydrogen) by weight, and ratio of hydrogen to carbon by volume.

Carbon.

5.3 volumes of CO_2 contain 2.65 volumes of carbon { assuming carbon to be gaseous.
14.1 ,, CO ,, 7.05 Ditto
0.5 ,, CH_4 ,, 0.25 Ditto
0.2 ,, C_2H_4 ,, 0.2 Ditto

Total carbon = 10.15 volumes.

Hydrogen.

First estimate hydrogen burnt to water, from the missing oxygen in exhaust:—

70.4 volumes of N_2 were originally associated with $70.4 \times 0.266 = 18.73$ volumes of O_2.
Also
5.3 volumes of CO_2 contain 5.3 volumes of O_2;
14.1 ,, CO ,, 7.05 ,,
Free O_2 = 0.1 ,,

Total O_2 accounted for = 12.45 volumes.
Hence

* Proceedings of the Institution of Automobile Engineers, vol. ii., 1907-08, page 99.

† Proceedings of the Institution of Automobile Engineers, vol. iii., 1908-09, pages 423 to 426.

O_2 used in formation of water = 18.73 − 12.45
= 6.3 volumes.
Hydrogen contained in water = 12.6 ,,
,, ,, CH_4 = 1.0 ,,
,, ,, C_2H_4 = 0.4 ,,
Free H_2 = 9.4 ,,

Total hydrogen 23 4 ,,

Weights of Fuel and Air.

10.15 volumes of carbon weigh $10.15 \times 12 = 121.8$
23.4 ,, hydrogen ,, $23.4 \times 1 = 23.4$

Weight of fuel 145.2

Air originally mixed with fuel = nitrogen × 1.266
= 70.4 × 1.266
= 89.1 volumes;

and 89.1 volumes of air weigh $89.1 \times 14.43 = 1287$.

$$\therefore \quad \frac{\text{weight of air}}{\text{weight of fuel}} = \frac{1287}{145.2} = 8.87,$$

$$\text{also} \quad \frac{\text{volume of } H_2}{\text{volume of } C_2} = \frac{23.4}{10.15} = 2.3.$$

Here the calculated mixture strength 8.87 agrees very closely with the measured strength 8.93, also the volume ratio of hydrogen to carbon in the exhaust is in close agreement with the same ratio in the fuel (C_8H_{14})—viz., 7 : 3 or 2.33 : 1. It is as well to note that, in all calculations of this kind, the fuel is assumed to consist entirely of carbon and hydrogen. Further, the hydrocarbons in the hexane and petrol products are taken to be C_2H_4, although their composition is unknown and the substitution of other hydrocarbons in place of C_2H_4 would considerably affect the calculated mixture strength, in spite of the small volume of the hydrocarbon constituent.

Again, the nitrogen, which is used for the determination of the original weight of air and oxygen, is found "by difference," and no allowance is made for water-vapour. Computations of the type just detailed have been made to determine the mixture strength from the composition of the exhaust for both strong and weak mixtures, and the results are set out in column 19 of Table I., page 289. The agreement between measured and calculated values, columns 2 and 19, is marked, especially with strong mixtures, and justifies the statement that the mixture strength can be calculated with a considerable degree of accuracy from the results of a complete analysis of the exhaust.

The author does not recommend the calculation of the mixture strength in preference to the employment of an exhaust-gas chart, since the former involves a complete analysis, taking from 2 to 5 hours, whereas the latter requires a partial analysis, taking from 35 minutes to 1½ hours; but he considers it important to point out that mixture strengths calculated from the exhaust are more accurate than has generally been supposed. The ratios by volume of hydrogen to carbon in the exhaust and in the fuel should agree if the analysis has been sufficiently complete to reveal all the constituents containing carbon and hydrogen. It will be noted that, for a given fuel, this volume ratio is fairly constant throughout—*vide* column 20, Table I. (page 289).

Having discussed the accuracy of the exhaust-gas chart, Fig. 3, the nature of the exhaust itself can be dealt with.

In the first place, the volume of mixture exploded—column 3, Table I.—has but little effect on the composition of the products. Such was not the case with benzene. Heavy hydrocarbons (or unsaturated hydrocarbons)—column 7—are practically non-existent, only slight traces being found in the products of strong mixtures. As to the hydrogen—column 11—its determination by palladium sponge is checked satisfactorily by taking two-thirds of the alteration in volume shown in column 9. This alteration in volume includes that due to the combustion of the combustible that forms the CO_2 in columns 10 and 13, whatever that combustible may be. The nature of the combustible in question is difficult to determine, because its quantity is extremely small, and the alteration in volume due to its combustion—column 12—appears to be a very variable quantity. This latter feature is no doubt due to impurities in, or incomplete combustion of, the oxy-hydrogen gas. This unknown combustible can be assumed to be methane—an assumption that has been made in calculating columns 17, 18, 19, and 20

(*To be continued.*)

TRADE WITH SPAIN AFTER THE WAR.—According to information supplied by H.M. Consul at Bilbao, and given in the *Board of Trade Journal*, local business men anticipate that after the war there will be a rush of Germans to Spain intent on doing business in and trading with that country. German firms will be less disliked in Spain than they are in countries with which Germany is at war, and they will doubtless be eager to regain and make the most of their Spanish business connections. Before the war Spain was flooded with cheap German goods, and it is reported that 75 per cent. of the machinery, tools, electrical fittings, household articles, cheap fancy goods, &c., in use in Bilbao is of German manufacture. Many of these goods are highly finished, but very poor in quality; nevertheless they are preferred by the Spanish purchaser on account of their cheapness. The present is, however, considered a good moment for introducing United Kingdom manufactures. H.M. Consul therefore suggests to United Kingdom firms that they should consolidate their connections and *clientèle*, so as to be able to compete against the expected German business effort. He adds that large numbers of Germans are now in Spain employed in obtaining information on every kind of subject, and no doubt the point of view of future trade is being carefully studied by them.

BOILER EXPLOSION IN LONDON.

A REPORT has just been issued by the Board of Trade, under the Boiler Explosions Acts, 1882 and 1890, in the case of a boiler explosion which occurred on October 4 last at Battersea Bridge, London. The boiler was owned by Messrs. John Mowlem and Co., Limited, Grosvenor Wharf, Westminster, and was of the vertical multitubular type and made of iron. It was made by the Lidgerwood Manufacturing Company, of New York, in 1903, and was 6 ft. 3 in. high by 3 ft. in diameter; the safety-valves, it was stated, were set to blow off at a pressure of 60 lb. on the sq. in. The boiler was not insured, but was inspected periodically by the owners' foreman engineer, who examined it on July 13, 1915. It was fixed on board the barge Nile, and was used for supplying steam to a pile-driver engaged in connection with repairs being carried out to Battersea Bridge. It was placed there on July 30, 1915, after a thorough overhauling, and the foreman engineer of Messrs. Mowlem's repairing works stated in evidence that he had adjusted the two safety-valves to lift at a pressure of 60 lb. per sq. in. by the gauge on the boiler, both valves blowing freely at that pressure. The boiler was originally built for a working pressure of 100 lb. per sq. in.; but, the report states, it was the custom of the company with this type of boiler to reduce the pressure by 10 lb. per sq. in. every three years, as, owing to no man-hole being provided, a satisfactory internal examination could not be made. Although the boiler was twelve years of age, it had not been in continual use, being employed from time to time in the various contracts on which the firm was engaged.

The explosion was of a violent nature; the shell crown-plate was bulged out and fractured, causing all the tubes to be withdrawn from the plate. The crown-plate was torn from the shell, the fracture occurring partly through the circumferential seam and partly through the plate. The fire-box was fractured for the full circumference at the bottom, with the exception of the portion in way of the fire-door; and, owing to the reaction, the fire-box barrel was blown through the deck of the barge, which deck was constructed of 4-in. deals. Considering the force of the explosion and the busy locality in which the boiler was working, it was fortunate that serious loss of life did not result. The engine-driver, a pile-driver, and two labourers suffered from injuries more or less severe and from shock, and a man who was cycling on Battersea Bridge at the time was hit by a falling piece of iron, with the result that his skull was fractured and his neck injured. A policeman was also injured, as was a fitter who was working in the London General Omnibus Company's garage, and was struck by a falling tube.

The Board of Trade state that the explosion was caused by over-pressure of steam due to a defective safety-valve. The fragments were examined after the explosion, and as far as could be ascertained the boiler had been in good condition, there being no signs of wasting, with the exception of slight grooving round the tubes in the crown-plate. The safety-valves, on examination, were found to be defective, the spring having been screwed down until the coils were touching each other, it being also in a rusty condition. The coils of the spring of the valve being found to be jammed together, the report states, leads to the supposition that some unauthorised person had tampered with the compression screw. This could easily have been done, as no ferrule was fitted between the head of the screw and the lock-nut.

Taking into consideration the fact that the fire had been lighted about three hours previously, that the stop-valve was closed, and that the safety-valve was inoperative, it was probable that there would, with this type of boiler, under the conditions existing, be a rapid rise of pressure. One of the two safety-valves had previously been removed on account of leakage, and the foreman engineer stated that he did not ascertain if the remaining valve was in working condition before giving his order to remove the other. The Board of Trade surveyor, in his report, states that it is to be regretted that neither the driver nor the foreman engineer did not try the remaining safety-valve, as a lever is provided on each valve for the purpose. Had this been done, it was probable that the explosion would not have occurred.

In sending the report to the Assistant Secretary of the Marine Department of the Board of Trade, Mr. A. Boyle, the Engineer Surveyor-in-Chief, makes the following observations:—

"The explosion was of a violent character, and it is extremely fortunate that the consequences were not as serious as they might have been. It seems clear that it was caused by over-pressure of steam, due to the defective condition of the only safety-valve with which the boiler was at the time provided, and it is not very creditable on the part of those responsible for the management of the boiler to allow a safety-valve to be removed without ascertaining that the remaining one was sufficient for the purpose intended, or to sanction the use of a safety-valve without means of preventing its being overloaded."

SWEDISH MINES IN GERMAN HANDS.—*Dot Nya Sverige* contains a remarkable article stating the number of mines in Sweden which have been acquired by Germans during the ten years preceding the war. The export from some Swedish mine-fields of very valuable non-phosphoric ores has risen from 30,000 tons in 1906 to 250,000 in 1913, and is still on the increase. In certain districts about 50 per cent. of the mines are in foreign hands. There are also several copper, zinc, and lead-mines owned by foreigners. The danger of this German economic invasion of the mine-fields has already been pointed out. It is interesting to note that a periodical with such pronounced German sympathies should have taken up the question.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia: The Commercial Intelligence Branch is in receipt of a copy of the Estimates of Expenditure of the Government of Western Australia from the General Loan Fund for the year ending June 30, 1916, providing for a total expenditure of 2,103,881*l.*, the chief items being as follow:—Railways and tramways (685,975*l.*), including additions and improvements to railways opened, 120,000*l.*; railway construction, rolling-stock, &c., 266,975*l.*; electric tramways at Perth, 88,000*l.*; electric power-station at East Perth, 182,000*l.* Harbours and rivers (157,883*l.*), including harbour improvements at Albany, Bunbury, Fremantle, &c., 140,100*l.*; jetty works, 17,000*l.* Water supply and sewerage (337,120*l.*), comprising water supply for towns generally and goldfields, sewerage works at Perth and Fremantle. Agriculture (540,074*l.*), including abattoirs, cold stores, canning works, &c., 121,000*l.*; assistance to settlers, industries, &c., 199,524*l.* Roads, bridges, &c. (59,000*l.*), including new roads and bridges, 10,000*l.*; public building, 30,000*l.* In connection with the above it may be noted that an Act of the Western Australia Legislature, assented to on December 7, authorises the raising of a sum of 1,245,000*l.* by loan for the construction of certain public works and for other purposes. A schedule to the Act allots, *inter alia*, 495,000*l.* for expenditure on railways and tramways, 107,000*l.* on harbours and rivers, 130,000*l.* on water supply and sewerage, and 102,000*l.* on the development of agriculture.

South Africa: With reference to the decision of the municipal authorities of Port Elizabeth to raise a loan for the purpose of carrying out a sewerage scheme, it is notified that, according to information received at the office of H.M. Trade Commissioner in South Africa, the municipality have now announced the issue of a loan of 300,000*l.* for general sewerage purposes.

Portugal: The *Diario do Governo*, Lisbon, publishes the text of a Bill to authorise the Government to call for tenders for the construction and working of a railway, the survey of which has already been carried out, from Setil to Peniche. It is also provided that construction work should commence within a maximum period of three months from the date of the granting of the contract, and be completed within three years.

Spain: With reference to the call for tenders by the Municipality of Barcelona for the carrying out of street drainage and sewerage works in that city, it is announced in the *Gaceta de Madrid* that tenders will be received, within a period of thirty days from March 3, for the carrying out of further similar works in Barcelona at a total estimated cost of 108,973 pesetas (about 4360*l.*). The conditions of contract contain clauses to the effect that at the first competition the materials to be used will be confined, with certain exceptions, to products of Spanish manufacture, but that, in the event of no decision being arrived at, a second competition, in which foreign products will be accepted, will then take place. In the latter event, Spanish products will have a 10 per cent. margin of preference over foreign.

Brazil: H.M. Consul at Porto Alegre writes, with reference to the contract for the repaving of Porto Alegre, that there appears to be a prospect of this work being commenced in the near future. By the terms of the contract an area of 500,000 square metres is to be repaved at a total cost of 223,200*l.* The *Diario Oficial*, Rio de Janeiro, publishes a Decree approving the plans presented by the Commissão Federal de Saneamento da Baixada Fluminense for the dredging of the Rio Tambicú, and also of the Furado Canal, which connects the Rio Macacú with the Guareindiba. The estimated cost of the works is 163,987 milreis (about 8200*l.*). The *Diario* also publishes a further Decree approving the plans presented by the Leopoldina Railway Company, Limited (British), of a metal bridge over the Rio Saracuruna, on the Norte Railway (State of Rio). The estimated cost of the undertaking is 232,295 milreis (about 11,600*l.*).

Argentina: The *Boletin Oficial* publishes a Decree, dated January 21, under the terms of which the Argentine State Railways Administration will present plans, within a period of four months from the date of the Decree, for the construction of viaducts and bridges over the Rio Salado on the Deán Funes-Laguna Paiva line of the Central Northern Railway, in substitution for temporary structures which have been erected. The *Boletin* also contains a Decree authorising the Argentine State Railways Administration to effect improvements on the lines of the Northern and Central Northern Railways, at a total cost of 835,844 pesos currency (about 73,000*l.*). A further Decree published in the *Boletin* grants a concession to Don Juan D. Evans for the utilisation of the waters of the Rio Percey for industrial purposes. The concessionaire must present to the Argentine Irrigation Department, within a year from the date of the grant of the concession, plans of the necessary works.

China: According to the *Hong Kong Weekly Press*, the Chinese Government has granted the request of the Chefoo Chamber of Commerce for the joint construction by the Government and merchants of a railway connecting Chefoo and Weihsien, at a total estimated cost of 10,000,000 dols.